Medicare Participating Heart Bypass Center Demonstration:

Final Evaluation Report: Volume I - The First Three years

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TABLE 6-14 DRG 107 AVERAGE COSTS, REVENUES, AND MARGINS PER DEMONSTRATION PATIENT, 1990-1993: OHIO STATE UNIVERSITY HOSPITAL, COLUMBUS

TABLE 6-15 DRG 106 MEDICARE DEMONSTRATION AVERAGE DIRECT COSTS PER PATIENT BY DEPARTMENT, 1990-1993: OHIO STATE UNIVERSITY HOSPITAL, COLUMBUS

TABLE 6-16 DRG 107 MEDICARE DEMONSTRATION AVERAGE DIRECT COSTS PER PATIENT BY DEPARTMENT, 1990-1993: OHIO STATE UNIVERSITY HOSPITAL, COLUMBUS

TABLE 6-17 SUMMARY OF COST AND PROFIT TRENDS: 1990-1993

1.0 INTRODUCTION AND OVERVIEW OF KEY FINDINGS

1.1 Rationale for the Demonstration

In 1980, the federal government spent $36.4 billion on the Medicare program (Letsch *et al.*, 1992, Table 4). By 1991, the figure had reached $120.2 billion, an average increase of 11.4% annually. For hospital care alone, the federal Medicare Program spent $26.4 billion in 1980 versus $73.3 billion in 1991 (Letsch *et al.*, 1992, Table 21). Spending on physician services rose even faster from $7.9 billion in 1980 to $32.8 billion in 1991.

The Health Care Financing Administration has been very active in responding to these high rates of program outlays. On the hospital side, the Congress passed TEFRA legislation in 1982 that put per case ceilings on hospital reimbursements. Then, a year later, it passed DRG prospective payment for all short-term acute hospitals receiving Medicare payments. In terms of physician reimbursement, the Congress passed, and HCFA implemented, the physician fee freeze in the mid-1980s, followed by overpriced procedure rollbacks in the late 1980s and, finally, the Medicare Fee Schedule in the early 1990s designed to link payments more closely to work effort and the costs of each service.

Besides legislated reform, HCFA also has undertaken many cost containment demonstrations. One approach involved negotiating global payment rates for all Part A and B inpatient services associated with bypass surgery. Expenditures on heart bypass surgery have been particularly worrisome. Every year, the government spends several billion dollars on the inpatient care for bypass patients. Outlays continued to grow rapidly in the 1980s with the growth in procedure rates. With the implementation of DRG per case payment to hospitals in 1983, the Part A payment per case for bypass surgery has been capped at the annual update in Medicare hospital rates nationally. However, the growth in Part B physician outlays remained unconstrained, except for rollbacks on the surgeon's fee. Mitchell (1993) estimates that total allowed charges grew 12-14% for bypass surgery from 1985-88, even after adjusting for updates in allowable fees.

A major concern of both hospital managers and policy makers in controlling inpatient costs for high-tech procedures is the asymmetry of financial incentives faced by hospital staff versus physicians. Currently, hospitals are paid for bypass surgery on a per case basis (primarily within DRGs 106 and 107). Except for extraordinary outlier costs, they are paid a fixed amount regardless of the intensity of care provided each patient. Although surgeons, like hospitals, receive a bundled fee for inpatient services, other physicians, by contrast, are paid for every additional service they provide, including routine daily hospital visits and consultations. Surgeons, too, are paid more for more complicated surgeries requiring more bypassed lesions.

Moreover, all hospital services are essentially "free" to physicians because they bear none of the financial risk of keeping patients in the ICU longer, or using more expensive drugs, etc. So long as physicians operate under different payment incentives, hospital managers have had difficulties implementing more efficient practice patterns. A global fee that includes physician services would align incentives and encourage physicians to use institutional resources in a more cost effective manner.

1.2 Overview of Demonstration Design

In 1988, the Health Care Financing Administration solicited bids from hospitals and physicians to participate in the Medicare Heart Bypass Demonstration. After initial review, 42 hospitals were requested to submit extensive formal applications that detailed their qualifications and bypass volumes. Applicants were then asked to give their best price covering all inpatient institutional and physician services for Medicare patients discharged in DRGs 106 and 107, bypass with or without catheterization. Twenty-seven entities submitted bids, and an expert panel of physicians reduced the list to ten finalists. At this point, Agency staff, with the assistance of staff from Lewin-VHI and Health Economics Research, the evaluation contractors, conducted an in-depth evaluation of each proposal. Ten criteria were used to rank applicants based on quality and price considerations. (See Chapter 3 for details.) The Agency then negotiated contracts with four applicants:

- St. Joseph's Hospital in Atlanta;
- St. Joseph's Mercy Hospital in Ann Arbor;
- Ohio State University Hospital in Columbus;
- University Hospital in Boston.

These sites were chosen based on price and other factors, including geographic dispersion. The intent was to maximize the policy information derived from the novel payment arrangement as well as to test the feasibility of negotiating and then paying bundled global rates.

Under the demonstration, Medicare paid each of these applicants a single global rate for each discharge in DRGs 106 and 107. This rate included all inpatient hospital and physician services. The standard Medicare hospital passthroughs were also included, i.e., capital and direct medical education, on a prorated basis. Any related readmissions were also included in the rate. Pre- and post-discharge physician services were excluded except for the standard inclusions in the surgeon's global fee. All four participants agreed to forego any outlier payments for particularly expensive cases.

Hospitals began receiving payments in May and June of 1991. The length of demonstration was set at three years, ending in June of 1994. Participants were required to assemble all physician bills along with the hospital discharge abstract and submit the package to HCFA Central Office for payment. The hospital and physicians were free to divide up the payment any way they chose. Rates were updated annually according to existing hospital prospective payment and physician fee schedule rules.

Applicants were required to collect a predetermined financial obligation from Medicare patients. This included any Part A hospital and Part B physician deductibles plus the 20% Part B coinsurance. Ordinarily, the coinsurance amount varies by the amount of physician services each patient receives, but under the demonstration the Agency set a fixed actuarial amount per discharge to conform to the (estimated) negotiated Part B amount.

The government placed few requirements on participants other than those already imposed by the program. Hospitals were still subject to the usual utilization review activities that monitored necessity for admission. Physicians were not allowed to balance bill patients, nor could they bill for outpatient services normally included in their global inpatient fee. When the Agency reclassified most DRG 108 bypass patients back into DRGs 106 and 107 in 1992, these patients became part of the demonstration as well. Similarly, when the Congress passed the Medicare Fee Schedule that rolled back many surgical fees, the Agency made downward adjustments in the Part B component of the global rates.

Unlike the current Medicare program, the Agency required that it have the right to review and approve any promotional materials used by the hospitals and physicians under the demonstration. One of the marketing strategies proposed by applicants was to forego the deductible and copays for patients without supplemental insurance. The Agency finally ruled against this request on the grounds that it would discriminate against third-part insurers (and their subscribers) who would still be liable. Providers were not willing to forego deductibles and copays on all demonstration patients.

In the spring of 1993, the government expanded the demonstration to include three more participants:

- St. Luke's Hospital in Houston;
- St. Vincent's Hospital in Portland, Oregon;
- Methodist Hospital in Indianapolis.

All six of the remaining ten applicants from the first round were invited to submit new bids, but only St. Luke's, St. Vincent's, and Methodist Hospital did so. These hospitals began receiving payments in the second quarter of 1993 under three-year contracts. The original four

hospitals all agreed to continue being paid global rates under the demonstration after their contracts ended in the summer of 1994.

1.3 Evaluation Issues

Many issues were addressed in the evaluation. Some of the more important ones included:

- **Feasibility**

Was it possible for the government to negotiate discounts with providers that included both hospital and physician services? Could this process be fair and efficient? What data and other requirements were required on the government's part? On the provider side, would any hospitals and physicians be able to work together and submit a single packaged rate? Could they provide the data necessary for the government to evaluate the quality of their services and the extent of the discounts they were offering?

- **Implementation**

In order to begin paying global rates, what payment processes had to be changed? What requirements would providers have to meet for payment? How should demonstration billings and payments be integrated with the on-going systems of Fiscal Intermediaries and Carriers? How should the patient obligations be determined? How would changes in Medicare payment policies be applied to the demonstration? What kinds of routine reporting by participants would be required?

- **Volume Growth**

Did the imprimatur of being named a Medicare Participating Heart Bypass Center result in increased bypass volumes among the participants? How did participants promote the demonstration? Did they increase volume at the expense of local competitors? How did competitors react to the demonstration?

- **Program, Beneficiary, and Hospital Savings**

How large were the discounts that the government negotiated with participants? How much did Medicare beneficiaries (and their insurers) benefit as a result of the discounts? Did post-discharge utilization and costs change as a result of bundling all inpatient physician services into a single rate? Did any gains in market shares of demonstration hospitals result in further program savings at the market level? By aligning physician with hospital incentives under a per case payment, did practice patterns change that generated lower hospital costs?

- **Patient Outcomes**

Did patient outcomes change under the demonstration, as measured by inpatient mortality and complication rates? Did one-year post-discharge outcomes change, as measured by mortality, angina relief, and readmissions? Were there any systematic differences in outcomes among participants?

- **Appropriateness of Care**

Did the overall level of appropriateness of care change under the demonstration? If so, did the changes vary by clinical presentation, i.e., stable vs. unstable angina, acute myocardial infarction? What was the extent of disease among demonstration patients and how did that change over the demonstration period?

- **Patient and Hospital Management**

Did physicians change the way in which they managed patients in the hospital under the demonstration? Were there changes in ICU, surgery, catheter lab, pharmacy, and routine nursing services? Were there any changes in the use of consulting physicians under a single fixed global payment? Did hospitals introduce significant management changes to lower costs and improve service efficiency over-and-above changes in patient management?

- **Marketing Programs**

How did participants market their selection as a demonstration hospital? Did they employ different strategies towards patients, referring physicians, and insurers? Were participants in a better position to compete for managed care contracts because of the

demonstration? What impacts did marketing have on volumes? How did competitors respond in their marketing efforts?

- **Physician Payments**

Once the hospital received the bundled payment, how was it divided up between the institution and physicians? How were consulting physicians that were not routinely involved in a case reimbursed? Did physicians share in any of the cost savings that may have resulted from changes in their practice patterns? What impact did the Medicare Fee Schedule rollbacks on certain bypass-related procedures have on physician payments?

- **Reimbursement Difficulties**

What problems did participants encounter in receiving payment from the government? What problems did they encounter in billing third-party payers for the supplemental insurance?

- **Achievement of Goals**

How satisfied were hospitals and physicians with the demonstration? Did they feel that the demonstration helped them gain volume and market share? Did it force them to improve their patient and cost reporting for management purposes? Did they feel that the alignment of incentives led to significant improvements in hospital and patient management? Did they believe that the demonstration resulted in a closer working relationship between the hospital and clinical staffs? Were participants disappointed with any aspect of the demonstration?

1.4 Evaluation Approach

To provide answers to these questions, the Health Care Financing Administration contracted with Lewin-VHI and Health Economics Research. Their interdisciplinary staff of economists, physicians, and marketing experts were responsible for assembling a variety of data bases and conducting numerous on-site interviews with participants as part of an extensive quantitative and subjective evaluation of the program. The staff also assisted HCFA in the evaluation of the bids of the ten finalists.

The principal data bases used in the evaluation included:

- all MedPAR discharge records for DRGs 106, 107, and 108 for four years, 1990-93;
- all National Claims History Part B claims for patients identified on the MedPAR files;
- detailed hospital micro-cost information on each patient;
- detailed clinical information on each demonstration patient;
- follow-up patient outcome status one year post-discharge;
- the Medicare enrollment file information on all demonstration patients;
- angiographic films and reports for a sample of 120 patients in six sites;
- detailed patient volumes, marketing, and referral information from all seven sites.

The Medicare claims were used to document national trends in Medicare bypass volumes, patient demographics, lengths of stay, mortality rates, and costs. Trends were decomposed by hospital location, teaching status, and bedsize. Physician costs were decomposed into three segments representing 30 days prior to bypass surgery, inpatient, and 90 days post-discharge. Inpatient physician costs were further separated by specialty. Finally, national Medicare bypass expenditure regressions were used to isolate the trend and hospital and patient factors explaining the variation in hospital DRG and hospital plus Part B physician expenditures.

When subsetted to the demonstration hospitals and their competitors in local markets, the claims data supported quantitative analyses of shifts in market shares and comparative differences in patient demographic mix, costs, and lengths of stay. These analyses involved statistical tests of the differences in shares and other characteristics between 1990, the baseline year, and 1993, the last year of the original demonstration.

The Part A and B claims data, along with the negotiated global prices provided by HCFA, were also used to measure the extent of program and beneficiary savings under the demonstration. Negotiated prices were compared with predicted Medicare prospective payment rates and physician inpatient outlays to derive the immediate savings from the demonstration. To test for shifts in services post-discharge, the other claims associated with demonstration patients 30-days prior and 90-days post-discharge were compared, year-by-year, with what might have been expected in lieu of the demonstration, based on 1990 average outpatient payments at each demonstration hospital updated by the national growth in outlays for the same two pre- and post-discharge "windows". Finally, any market share savings were

derived by taking the difference between the negotiated prices and what other competitors were being paid by Medicare and multiplying by the shift in cases.

The micro-cost information was used to evaluate trends in institutional costs and profits on demonstration patients. Each of the four original participants submitted cost data on each patient by individual service and/or by department for a baseline 1990 period and for the 1991-93 demonstration period. Average total and variable costs were derived, then compared, showing overall gains in costliness and profits per case. Per case costs, within DRG, were also decomposed by department to isolate the source of any efficiency gains.

Every demonstration hospital provided a set of clinical information on each patient, including discharge status (died, other), risk indicators, comorbid conditions, admission priority, type of coronary heart disease, age, gender, height, whether they had had a previous bypass operation, and ejection fraction. Additional information was provided on disease anatomy, e.g., number of lesions, percent occlusion by lesion, and intra- and post-operative complications, e.g., return to the operating room for bleeding, infection. Extensive descriptive analyses were performed comparing the seven hospitals in terms of mortality, stratified by risk factor and other relevant variables. Logistic analyses were then conducted explaining inpatient mortality, complication rates, and lengths of stay. The demonstration effect was tested in these models using a monthly time trend over the demonstration period. The mortality analyses were extended to 90-day and one-year follow-up using the Medicare enrollment files that record dates of death that may have occurred after discharge.

To test for any changes in the appropriateness of bypass surgery, a special panel of clinical experts was convened to rate the appropriateness of bypass surgery along several dimensions, including clinical presentation, surgical risk, number and type of arterial vessels occluded, extent of drug therapy, and ejection fraction. These ratings were merged onto the clinical data base according to each patient's mix of appropriateness criteria. Descriptive and multivariate analyses were then performed testing the change in appropriateness ratings depending upon the period in which the patient was discharged.

Appropriateness depends in part on the degree of vessel stenosis, or blockage. A concern over systematic differences in physician interpretations of the degree of stenosis resulted in a methodological study in which six of seven demonstration hospitals voluntarily submitted 20 films and angiographic reports for reinterpretation by an expert investigator. Again, descriptive and multivariate analyses were performed on over 300 lesions reported for the 120 patients using either the visual or computer-generated differences between the hospital and the expert as the dependent variable.

How successful hospitals were at marketing the program was determined by collecting detailed information from each site on their Medicare and non-Medicare bypass volumes. Data

was also gathered on the location of patients and referring physicians. Descriptive analyses of trends over time in volumes and shifts in referrals were then conducted.

In addition to the quantitative analyses using primary and secondary data, a single team of three evaluators visited all seven sites once and the four original sites a second time for in-depth interviews with managers and clinical staffs. These interviews were designed to fill in the gaps and help explain the results of the quantitative analyses. Interviews were conducted with hospital CEOs, COOs, CFOs, demonstration managers, department managers, marketing and managed care directors, billing/collection personnel, micro-cost data managers, operating room and floor nurses, and utilization review and quality of care directors. Interviews were also conducted with thoracic surgeons, cardiologists, anesthesiologists, catheter lab clinicians, and other consulting physicians. Questions regarding operational changes were asked of each respondent and whether they were the result of participating in the demonstration. Respondents were also asked why they decided to participate, how successful the demonstration had been, and what problems were encountered.

To supplement the interviews in the demonstration hospitals, interviews were conducted in two competitor hospitals with managers and physicians. (Attempts to interview in the two other original sites were unsuccessful.) These interviews focused on marketing and competitive issues.

1.5 Summary of Findings

1.5.1 National Trends in Medicare Bypass Surgery

After rising steadily for twenty years, the number of Medicare heart bypass cases appears to have peaked at 150,000 in 1992, before declining slightly in 1993. Over the four-year period, 1990-93, total Medicare program costs on bypass surgery alone increased by roughly $1 billion to **$5.5 billion by 1993.** This estimate includes not only an extra $870 million in hospital payments, but a **50% increase in 90-day post-discharge outlays** as well. Home health and skilled nursing costs either doubled or tripled over the period.

National Medicare inpatient mortality rates fell from 1990 through 1993 by one percentage point to 5.5% in 1993. Rates were 1.5 points higher in small (under-200 bed) hospitals. Significant differences in inpatient mortality rates exist across hospitals more generally. Ten percent of the roughly 800 bypass hospitals have mortality rates less than 2% versus another 10% with rates above 9.5%. Hence, the issues of quality and regionalization of bypass surgery in larger hospitals provide a strong motivation for the demonstration.

Substantial reductions in inpatient stays also took place while mortality rates were falling. As recently as 1990, the average bypass stay was 15 days. Three years later, it had

fallen to 12.5 days. Yet, as with mortality rates, significant variation in lengths of stay of nearly a week remained between the top and bottom 10% of hospitals.

Despite shorter stays, **Medicare outlays per case for bypass surgery**, including a 90-day post-discharge follow-up period, **rose 7.2% over three years to $37,400**. Inpatient costs, including associated physician services, rose $1,500 to $30,905; post-discharge costs rose by $900. When hospital location, size, and patient age and gender are controlled for, surgery in **major teaching hospitals cost the government almost $9,000 more** than in nonteaching hospitals, including both institutional and physician bills.

1.5.2 Feasibility of Bundled Payment

The federal government received almost 200 letters of interest to its initial request for bids to bundle both Medicare Part A hospital and Part B physician services. Forty-two qualified bidders were requested to apply; 27 responded with full bids. Of these, four hospitals were chosen initially, later expanded to seven. Thus, it is clear that **many hospitals can work jointly with their medical staffs to develop a single bid**.

Without question, significant data are required on the applicant's part to establish a bid for all services. The Health Care Financing Administration also requires all hospital and physician bills associated with previous discharges from applicants in order to evaluate the discounts being offered and how they relate to average payments elsewhere in the local market. Fortunately, **HCFA's new 100% claims files support such detailed evaluation**.

Finally, through a series of follow-up questions, hospitals and physicians were able to answer many detailed questions relating to quality assurance, components of the bid price, what services and specialties were covered, the definition of related readmissions covered under the global rate, and similar technical questions. All successful applicants were also **willing to forego any outlier payments and balance billing**; thereby bearing all the risk for costly cases.

1.5.3 Implementation Issues

Major changes in reimbursement methods were required under the demonstration. First, **hospitals and physicians were prohibited from billing their Fiscal Intermediaries and Carriers**. Instead, they had to assemble a package of bills and submit them to HCFA Central Office for payment. For payment, the package had to include the hospital discharge abstract plus the three principal physician bills (surgeon, anesthesiologist, and cardiologist).

Hospitals, in order to avoid double billing carriers, had to **identify prospective demonstration patients as soon as possible.** It is often several days before an inpatient is operated on. During this time, many physician consultants may have seen the patient and already billed for services rendered. Hospitals developed elaborate identification protocols to avoid most of these situations, but in some cases they still must reimburse carriers for overpayments.

Determining the patient's obligation was a challenge. The government decided that every patient discharged in the same DRG from the same demonstration hospital should be liable for a **fixed coinsurance amount,** after paying any outstanding deductibles. Ordinarily, patient responsibilities vary depending upon the number and kinds of physician and supplier services they use while an inpatient. Developing a fixed actuarial amount was a challenge in determining a typical bundle of physician services. Even more difficult was the hospital's task of collecting the fixed obligation from third-party supplemental insurers (see below).

1.5.4 Volume Growth

Over the first two and a half years of the demonstration, the **two nonacademic medical centers experienced statistically significant increases in Medicare bypass market shares.** University Hospital in Boston had a significant decrease in its share while Ohio State University Hospital had no change in market share. Among the three new participants who were under the demonstration for only the last 8 months of 1993, St. Vincent's Hospital in Portland experienced a significant increase in market share prior to entering the demonstration while Methodist Hospital in Indianapolis had a decline in market share.

All seven hospitals exhibited DRG proportions that differed from their local competitors. Hospitals in Atlanta, Boston, Portland, and Houston had disproportionately more DRG 107 referral patients than their competitors, implying that they serve more as referral institutions. (DRG 107 patients have had their angiography completed on a separate admission, usually at another hospital.) Hospitals in Columbus and Ann Arbor had remarkably high proportions of cases in DRG 106 compared to their competitors. Both nonacademic medical centers in the original demonstration group saw significantly fewer minority patients than did their competitors.

When all competitor hospitals were pooled across sites, **St. Vincent's in Portland had stays that averaged 3.6 fewer inpatient days; St. Joseph's Hospital in Atlanta averaged 3-day shorter stays.** This was true controlling for DRG mix and patient age and gender. Compared to their own set of competitor hospitals, both St. Joseph's hospitals in Atlanta and Ann Arbor had stays roughly 1.5 days shorter on average. **All seven hospitals exhibited strong declines**

in lengths of stay ranging from one-half to one full day per year. Only University Hospital, however, had declines in stays that exceeded the downward trend taking place among local competitors.

1.5.5 Program, Beneficiary, and Hospital Cost Savings

From the start of the demonstration in May-June, 1991, through December, 1993, the **Medicare program saved $15.3 million on bypass patients** treated in the four original demonstration hospitals. The average discount amounted to roughly **14%** on the $111 million in expected spending on bypass patients, including a 90-day post-discharge period. Ninety percent of the savings came from HCFA-negotiated discounts on the Part A and B inpatient expected payments. Another 8% came from lower-than-expected spending on post-discharge care, while 2% came from shifts in market shares in favor of lower-cost demonstration facilities.

In addition, **beneficiaries (and their insurers) saved another $2.3 million** in Part B coinsurance payments. Thus, total Medicare savings are estimated to have been $17.6 million in 2 1/2 years.

St. Joseph's Hospital in Atlanta generated $5.5 million in program savings; the most of any hospital. Of this total, $4.2 million came from negotiated discounts and another $1 million from post-discharge savings. Savings from its gain in market share were quite minor. University Hospital and St. Joseph's Hospital in Ann Arbor both generated $3.4 million in savings. Ohio State University Hospital generated $2.9 million in savings, the least of the original four hospitals, in spite of the fact that it had by far the largest negotiated inpatient discount per case (roughly $10,000 including teaching costs and other pass-throughs). It also saw the fewest demonstration patients.

The demonstration clearly saved the program money, but what about hospitals that offered discounts to participate? Did the alignment of physician and hospital incentives result in less costly care as well as lower program costs? **Three of four original hospitals were able to make major changes in physician practice patterns and hospital operations that generated significant cost savings.** St. Joseph Mercy and St. Joseph's Hospitals, along with University Hospital in Boston, experienced absolute decreases in per case costs ranging from 2% to over 23% between 1990 and 1993, depending on DRG and hospital. The Atlanta hospital had the highest average reduction: 9-13% per case in the two DRGs. Assuming 5% annual inflation in hospital input wages and other prices, one could expect a three-year increase of over 15%, not counting the secular trend towards more intensive care of older patients with more coronary vessel disease. Thus, the reductions in real resource costs in three hospitals may have ranged between 18% and 40%. Ohio State University Hospital, by contrast, experienced average cost

increases in both DRGs of 10 to 24%. After adjusting for expected inflation, however, these rates are not exceptionally high.

The three hospitals with declines in average costs experienced statistically significant declines of 10-40% in direct ICU and routine nursing expenses. The two nonacademic medical centers also had **significant declines of roughly 30% in pharmacy costs per case.** Laboratory costs fell between 20 and 60%. Operating room costs, by contrast, rose 10-20% across all institutions, but, again, this is not controlling for wage and other price increases.

Declining costs per case in Atlanta resulted in increases in average margins of $3-4,000 from 1990 to 1993. St. Joseph Mercy achieved an $8,500 increase in DRG 106, although margins fell by $1,300 in DRG 107 even though costs fell slightly. Ohio State University Hospital experienced major declines (=$7-10,000) in average per case margins due to a combination of sizable initial discounts to HCFA, no updates for three years, and 10-24% increases in per case costs.

Average margins reflect long-run profitability per case. What is more important to financial managers is short-run profitability based on variable margins. A demonstration patient will be profitable if payment more than covers the additional costs incurred plus contributing something towards fixed costs. On this basis, **all four original demonstration hospitals enjoyed significant positive variable margins.** St. Joseph's Hospital in Atlanta increased its variable margins by 80-111% while St. Joseph Mercy in Ann Arbor increased its DRG 106 variable margin by 62%. By contrast, the **two academic medical centers saw their variable margins decline** by 12-19% in University Hospital and 45-68% in Ohio State University Hospital.

1.5.6 Patient Outcomes

By the end of 1993, over 3,500 discharges were available for testing demonstration effects on clinical outcomes. (Several hundred more cases were available from the three new hospitals, but they were excluded from most analyses due to the short time they were in the demonstration.) **Holding many patient risk factors constant, no statistically significant trend in inpatient mortality rate was found.** While a one percentage point reduction in Medicare inpatient mortality exists in the national claims data, it was not possible to adequately risk-adjust this estimate for comparison. **The four demonstration hospitals also had much lower overall inpatient mortality rates (4.1-4.9% averaged over 1991-93) compared with the national rates (6.5% in 1990; 5.5% in 1993).** One of the four hospitals was found to have significantly reduced its inpatient mortality rate over the course of the demonstration. Individual trends in the other three hospitals were statistically insignificant.

No statistical difference was found in the overall inpatient mortality rates of the four hospitals regardless of whether patient severity and other risk factors were controlled for. Key risk factors controlled for included whether the patient had had a previous bypass, in which case the risk of dying was 4.5 times higher, whether he/she required the insertion of a balloon pump, thereby tripling the risk of dying, or if he/she was admitted on an emergency basis (2.4 times more likely to die), or over 80 years old (2.5 times more likely to die), or being admitted with renal disease (2.2 times more likely to die). Over the course of the demonstration, there was some evidence of a growing severity in case mix, including a higher percentage of patients over 80 and with comorbid conditions.

Using one-year follow-up information on a subset of patients discharged through December, 1992, **no trend was found in the likelihood of dying within one year,** controlling for other inpatient risk factors.

Multivariate analysis also showed a significant impact of post-operative complications on inpatient mortality rates. Renal failure, for example, increased the risk of dying by over 8-fold while return to the operating room for bleeding tripled the likelihood. These complications, naturally, were only controlled for after interpreting the trend and hospital differences separately. **A significant, positive, trend in the rate of complications was found over the demonstration period (at the 10% confidence level).** This was true controlling for patient risk factors. Nevertheless, this **did not produce an upward trend in mortality.** It is also quite likely that most patient complications are outside the hospital's and surgeon's control and may have been increasing in frequency due to unmeasured changes in patient severity.

1.5.7 Appropriateness of Care

Under the assumption that no demonstration patients were candidates for angioplasty, 97.7% of the bypass operations among all seven hospitals fell into the appropriate range according to the criteria of an expert panel of surgeons and cardiologists. **If every patient were considered a candidate for angioplasty, then only 72.7% of operations would have been deemed appropriate;** the rest being equivocal or inappropriate. Alternatively, .1% of patients could be considered inappropriately operated on if not a candidate for angioplasty versus 3.7% if all were candidates.

Given available clinical information, it was impossible to classify patients as to whether they could have undergone angioplasty. However, it seems reasonable to assume that the majority were not candidates. First, each participating hospital has a very active, growing, invasive cardiology service. All surgeons admitted that they were losing patients to angioplasty and that the severity of the patients they were operating on was increasing as a

result. Second, almost a quarter of patients had significant left main disease which is generally not considered treatable by angioplasty. Another 50% had triple-vessel disease which, although treatable by angioplasty, is still considered best treated by surgery in many cases. Nevertheless, the striking difference in the percentage deemed appropriate under alternative assumptions leaves open the possibility of differences. It was also disappointing that 22% of cases could not be classified due to missing data on exercise stress tests, disease anatomy, or ejection fraction. Practically all of the asymptomatic patients (roughly 4% of the entire sample) had to be dropped from the appropriateness analysis due to missing data on stress tests and ejection fractions.

No significant time trend was found in the overall average appropriateness rating of patients discharged from the four original hospitals, regardless of whether they were candidates for angioplasty or not. A slight downward trend in appropriateness was found among patients with unstable angina, left main, and 3-vessel disease. Any trends, however, remained well within a clinical margin of error in quantifying appropriateness.

Statistically significant differences were found in the average appropriateness level among the four hospitals but were of little clinical relevance due to their small absolute size. With nearly 3,000 observations, almost any difference was likely to be significant.

Coronary angiography results are one of the major determinants of the choice of treatment for coronary artery disease as well as the overall necessity of intervention. A separate, blinded, evaluation of 119 angiogram films from six of seven hospitals in 1993 found that **hospitals' estimates of the extent of stenosis, or occlusion, was significantly greater than those based on quantitative angiography**. Hospitals' visual estimates were also 6-15 points greater (on a scale of 1 to 100) than the expert visual estimates. Multivariate analyses showed one hospital consistently understated the degree of stenosis by 10-15 points relative to other participants. Two other hospitals were 5-8 points lower than the three hospitals with the highest overestimates.

Hospitals' overestimates varied inversely with the degree of stenosis, with more accurate readings at higher levels of occlusion. Angiographic quality was poor in 5-35% of cases depending upon hospital. Moreover, many catheter reports were incomplete with respect to clinical indications for catheterization, type of contrast agent, number of catheters used, etc.

1.5.8 Patient and Hospital Management

Three of four original demonstration hospitals made major improvements in their micro-cost data systems. A fourth hospital remained on the traditional departmental cost-to-

charge system of patient cost finding. This caused serious problems working with surgeons in trying to change practice patterns. **Only where hospitals could link specific services to patients and attach meaningful direct costs to them were they able to convince physicians of the need for more cost effective decision making.** Hospitals with detailed cost systems were able to conduct special studies in the operating room, the pharmacy, the ICU, and the catheter lab, that showed surgeons the frequency of brand and generic drugs, costly angiographic agents, etc.

Interestingly, few of the financial managers closely monitored the cost and profitability of demonstration patients. Rather, they hired an outside consultant to work with surgeons to change practice patterns. Comparative data from other hospitals provided by the consultant seemed crucial in supporting cost-effective drug substitutions and reductions in resource use.

A primary focus was the four components of length of stay: admission to catheterization; catheterization to surgery; ICU length of stay; and post-ICU length of stay. As a result, **most hospitals reduced ICU stays by one full day and routine stays by another two days.**

Hospital managers also noted that the best costing system was of limited use without the surgeon's active involvement. **Aligning surgeon with hospital incentives to reduce costs was absolutely critical in changing practice patterns and improving department efficiency.** In the one hospital without a micro-cost system, the surgeons resisted practice changes and little was accomplished during the first two years of the demonstration. (Other barriers to change are summarized below.)

The two nonacademic institutions made major staffing reductions over the course of the demonstration in response to declining inpatient utilization. Shorter ICU stays meant more turnover and fewer nursing days per patient. Early extubation and quicker ambulation were key factors.

Hospitals also introduced a **major innovation by designating Clinical Nurse Specialists to be in charge of each bypass patient's stay.** Their main job was to assure a smooth transition from service to service, to avoid costly complications, and to improve communications among specialists making clinical decisions. They also reviewed standing orders and recommended changes. It is interesting that specialists in other areas such as orthopedics resisted hospital attempts to introduce nurse specialists. Managers felt that they had no financial incentives to change their practice patterns.

Another novel change was the implementation of **same-day surgery for DRG 107** patients. Again, physician incentives to avoid an extra day's stay helped, although many now seem challenged to get patients in and out of the hospital as quickly as possible regardless of payment methods. Nurses argued that changing both physician and patient mindsets about

how long they would be staying was key; that several days were unnecessary in the recuperation process and were better spent at home.

Pharmacists cited **several drug substitutions** that explained the savings reported earlier. One hospital reported saving $50,000 annually in cardioplegic solutions during surgery. Two other hospitals were saving $100,000 per year by substituting generic for brand narcotics. Twenty to forty thousand dollars was saved in vasopressors, anti-coagulants, and diuretics at a couple of participating hospitals. Pharmacists emphasized the importance of having the surgeon on their side, inviting them to meetings, discussing possible substitutions, asking for special studies.

Operating room managers observed a significant increase in the complexity of bypass surgery which they ascribed to angioplasty and fewer single and double-vessel bypasses. Nevertheless, they saw improvements in operating room times. Bypass operations that used to take 8.5 hours in 1992 were taking 5 hours in 1994, for example. Due to improvements in angioplasty, none of the hospitals kept an operating room and team standing by for failures. Now, it is on a next-available basis.

Efficiencies have been realized in the catheter lab as well, beginning with the substitution of ionic for nonionic contrast agents. One hospital saved $500,000 annually by using the cheaper agent half the time, without adverse reactions. With the cardiologists' support, managers have been able to narrow the number of device vendors from seven to two, thereby increasing their negotiating power and getting greater discounts.

1.5.9 Marketing Programs and Local Competition

Competition increased markedly in all four market areas, according to both demonstration managers and local competitors. First, hospitals could no longer rely on cost-based reimbursement. Second, managed care plans were very active in all four areas. Third, the diffusion of new catheter labs were having profound effects on referral patterns. And fourth, a few local competitors were being very aggressive in their marketing and networking with local physicians.

All four hospitals engaged in direct patient advertising, but **emphasized quality, not lower price**. This was particularly true of the nonacademic medical centers who concentrated on building a national reputation (and succeeded). The imprimatur of being a Medicare Heart Bypass Center was marketed heavily as a quality indicator to reassure patients when referred by physicians or managed care plans to their facility. By contrast, the academic medical centers found themselves switching marketing strategies away from the "pursuit of science "to a" caring environment".

The two nonacademic medical centers, as well as like competitors, were very active building referral networks. Deans in a couple of the academic hospitals, by contrast, were slow to react to the changing heart market and continued to espouse a "they will come" philosophy. Finally, when volumes dropped precipitously, surgeons and marketing staff convinced them to emphasize clinical care much more. Still, building referral networks for academic hospitals is difficult because of the tensions surrounding admitting privileges and lack of outside physician access to patients once admitted.

All four hospitals felt they were in a much better position to negotiate managed care contracts because of the demonstration. "We have expensed the experience," as one manager put it, implying that the hospital was forced to make the front-end investment in data systems, physician relationships, billing and collection systems, and critical care nurses that was now being put to use in the private market. The two nonacademic medical centers, again, had negotiated several global heart contracts with Delta, Prudential, and Aetna in Atlanta, and with First American Bank, and Consumers' Power in Ann Arbor. Weak data systems, high teaching costs, HMOs seeking full service contracts, and even resistant surgeons, held back the academic medical centers in negotiating bundled rates for heart care.

Interviews with managers and surgeons of academic medical centers, both in and out of the demonstration, highlighted major obstacles in a global budget environment. First, and foremost, they have a teaching and research mission and a cumbersome bureaucracy to overcome in responding to a fast-moving market. Closed staffs, limited operating room time, inefficient residents, very costly overhead services, impersonal community image; all constrain how far they can go towards expanding the clinical side of their operations. Years ago, these hospitals were totally dominant in their markets for complex bypass surgery. Today, many nonacademic hospitals are performing bypass surgery and angioplasty. Academic reputation alone is not enough to assure a viable number of bypass patients. Their far-flung referral networks were shrinking as new providers opened up around the state, forcing them to concentrate their marketing efforts locally. Finally, some academic surgeons are not anxious to compete for patients by changing practice patterns and lowering costs, which they see interfering with their teaching obligations. This raises the question of who will pay for teaching under a comprehensive managed care system of global budgeting.

1.5.10 Physician Payments

The negotiated global price between the government and the participants was based on separate estimates of Part A hospital and Part B physician outlays. Bidders then discounted each component either across the board or differentially by category. All four original hospitals

began allocating the single payment according to amounts agreed-upon in their bid. The four major specialties always involved in a bypass admission, namely, **the surgeon, the anesthesiologist, the cardiologist, and the radiologist, all received fixed capitated amounts** regardless of the services provided different patients. Consulting physicians were paid their regular allowable Medicare fees out of a set-aside pool in the Part B component. A percentage holdback on payments to the four capitated physicians was used to pay these fees. Any savings on the pool at year's end were returned to them.

The fact that consulting physicians could not bill Medicare directly proved contentious in several sites. Surgeons also cut back on their use of consultants, which aggravated them even more. In one site, pulmonologists, neurologists, and other consultants alleged that the quality of care was being compromised. When hospital management asked that they provide evidence of poorer quality, they were unable to do so.

As the demonstration progressed, two important changes took place in physician payments. First, the Congress introduced the Medicare Fee Schedule which had the effect of reducing HCFA payments on the Part B component of the bundled payment. No hospital adjusted their physician payments for the reduction; hence, **physicians under the demonstration were effectively sheltered from RBRVS rollbacks** on bypass surgery, catheterization and other overpriced procedures. Hospitals also made some minor adjustments in radiologists' payments (downwards) and cardiologists' payments (upwards) for technical reasons or errors in original estimates.

The second change in physician payments came from **sharing in hospital cost savings in the two nonacademic medical centers.** In Ann Arbor, St. Joseph Mercy "shared" the savings it realized from changes in surgeon practice patterns by extending them more operating room time and by converting their physician assistants in surgery and nurse specialists into hospital employees. In Atlanta, St. Joseph's Hospital instituted a Cost Reduction Allocation Program that provided bonuses to individual surgeons based on documented savings to the institution. To be eligible, the surgeon had to meet stringent quality and volume criteria. The bonus formula assured every surgeon of receiving at least the originally negotiated payment, thus insulating them from RBRVS rollbacks, plus one-quarter of any hospital cost savings they personally generated.

A final benefit to physicians was the willingness of each hospital to take responsibility for collecting any deductible and coinsurance amounts on both Part A and B. In general, physicians were paid promptly by the hospital upon discharge or within two weeks, except for late billers. Delays of several months in collecting the coinsurance from supplemental insurers resulted in significant cash flow problems for hospitals instead of physicians.

1.5.11 Reimbursement Difficulties

The demonstration involved major changes in reimbursement arrangements. First, providers had to bundle all physician inpatient bills with the hospital bill and submit them to HCFA Central Office for payment. No physician could bill carriers for inpatient services provided demonstration patients. Second, HCFA developed a flat copay for each patient by hospital and DRG.

According to providers, **patients were quite pleased with a single copay amount**. This simplified the payment process. They also liked the idea of a bundled copay amount for both hospital and physician services.

Hospitals, in general, were also **pleased with the prompt payment received by HCFA** Central Office, which was done by wire within thirty days. The one difficulty with came with **delays in updating rates for the Medicare Fee Schedule in the first quarter of 1994**. Instead of continuing to pay under the old rates, HCFA stopped paying any discharges from January through mid-April until it established the new rates. This **created a cash flow problem of several million dollars until it was resolved**.

Supplemental insurers responsible for paying patient deductible and coinsurance amounts **were uniformly displeased** with the flat actuarial payment calculated by HCFA. It was incompatible with their computer systems that required itemized charges, services, and payments by CPT code. Also, patients differed in their policies in terms of coverages, deductibles, and coinsurance amounts. A flat rate assumed all patients had identical supplemental policies. Many insurers also wanted to pay less when their patients used fewer physician services. In fact, the Medicaid programs in Michigan and Ohio refused to pay any amounts based on the flat rates for joint Medicare-Medicaid eligibles, arguing that their fee schedule was less than the flat rate. One insurer captured the feelings of many others by noting that "we didn't agree to participate in the demonstration". While the government has made extraordinary efforts to explain the change to insurers, it still regards the supplemental payment issue to be a provider problem. In fairness, HCFA explicitly adjusted the Part A and B amounts of the global payment so as to underestimate the average patient obligation.

Certainly, **the single largest administrative burden for hospitals under the demonstration involved billing and collection**. Every site significantly underestimated both the effort to assemble a complete package of bills and invoice the government as well as trying to collect the supplemental insurance. HCFA, the sites acknowledged, made many concessions and contacted many insurers, but the reimbursement changes inevitably required a whole new layer of billing/collection staff and procedures. As costly as it was, one financial manager

considered it "expensed experience" that had to be made in order to win private sector contracts of a similar nature.

1.5.12 Achievement of Goals

Overall satisfaction with the demonstration was mixed. Some goals were achieved, some were not. Some hospitals were more successful than others. All sites were hoping to increase their bypass volumes and market shares. **The two nonacademic hospitals were quite successful while the two academic centers had either constant or declining market shares.** The failure to increase volumes at Ohio State University Hospital was particularly distressing given the large discounts they negotiated. **Several hospitals felt that the government had abandoned them by not actively promoting the demonstration or allowing them to waive patient copays for the uninsured.**

On the positive side, **three of four hospitals did sign major new private managed care contracts bundling payment of heart surgery.** Most had made the necessary investments in data systems, joint physician contracting arrangements, changes in practiced patterns, and new billing systems. The one hospital that failed to make data investments had major contracting problems with their physicians.

Certainly, **the most salient accomplishment of the demonstration was the reduction in hospital costs in three of four hospitals.** As one demonstration manager put it, "we set a target of reducing our bypass costs by $1,000, and we did it." While a goal in most hospitals, there was some skepticism that physicians would change their practice patterns. Everyone in three hospitals were surprised at how quickly and how dramatically physicians were able to reduce lengths of stay, substitute generic for brand drugs, and reduce unnecessary testing and other services. In this regard, surgeon support for the clinical nurse specialists implementing critical pathways was crucial. In the one hospital where surgeons resisted attempts to change practice patterns, costs continued to rise.

Another goal of hospital staff was to achieve a closer working relationship with their physicians. All four hospitals felt they had achieved this goal, although tensions remain in some places with surgeons and consulting physicians. **Aligning physician and hospital incentives, respondents agreed, was key to the change in attitudes.**

Although quality improvements were never an explicit goal--all four hospitals felt they were providing high quality already--nurses in a couple of institutions believed that quality had improved. The primary reason was the increased emphasis of surgeons and other physicians on avoiding complications. The fact that complication rates rose slightly during the

demonstration is inconsistent with their subjective impressions, however, and may be due to changes in coding or unmeasured increases in patient severity.

The one uniform disappointment was the difficulties encountered in billing and collection. All sites felt they should have received extra payments to cover the novel billing arrangements. Now that internal procedures and computer systems are in place, however, these sunk costs are felt to be outweighed by enjoying the continuing imprimatur of being a Medicare Heart Bypass Center.

2.0 NATIONAL MEDICARE TRENDS IN HEART BYPASS SURGERY: 1990-93

2.1 Introduction: The Heart Bypass Demonstration in Perspective

This chapter presents trends in heart bypass surgery from 1990 to 1993 for the nation as a whole. National trends are presented to provide a background to the focused evaluation and to serve as a point of reference in measuring the performance of the participating demonstration hospitals and their competitors. The national statistics presented include the number of hospitals performing heart bypass surgery on Medicare beneficiaries during the four years included in the analysis, the number of discharges, the distribution of volumes of cases per hospital, trends in patient characteristics (age, gender, and race), mortality rates, lengths of stay, and Medicare program outlays on bypass surgery.

2.2 Data Sources and Methods

Data for this study come primarily from two sources: HCFA's MedPAR and National Claims History data files. The file construction process is summarized in Exhibit 2-1.

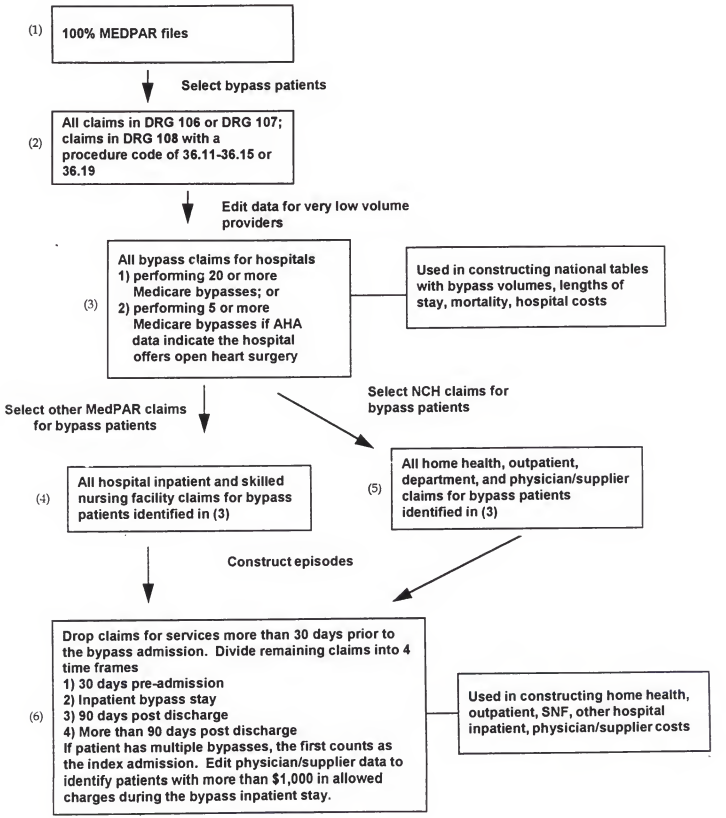
2.2.1 MedPAR Data

The data for inpatient hospital stays and skilled nursing facility (SNF) stays come from the Medicare MedPAR claims files for 1990-93. The MedPAR files contain a wealth of information on the inpatient stay including date of admission, date of discharge, length of stay, discharge status (alive/dead), DRG, diagnostic and procedure codes, and expenditures to the facility for the inpatient stay.

2.2.1.1 Selection Criteria

The first step in analytic file construction was to extract all Medicare CABG surgeries identified by the DRG and procedure codes listed above for patients discharged from January 1990 through September 1993. Coronary Artery Bypass Graft (CABG) surgery is primarily found in two DRGs: DRG 106, Coronary bypass with cardiac catheterization; and DRG 107, Coronary bypass without cardiac catheterization. Patients who receive their angiographic examination on the same admission as their bypass surgery fall into DRG 106, while those receiving angiography elsewhere prior to the bypass admission fall into DRG 107. If a patient

EXHIBIT 2-1 File Construction


(1)
100% MEDPAR files
Select bypass patients
(2)
All claims in DRG 106 or DRG 107; claims in DRG 108 with a procedure code of 36.11-36.15 or 36.19
Edit data for very low volume providers
(3)
All bypass claims for hospitals
1) performing 20 or more Medicare bypasses; or
2) performing 5 or more Medicare bypasses if AHA data indicate the hospital offers open heart surgery
Used in constructing national tables with bypass volumes, lengths of stay, mortality, hospital costs
Select other MedPAR claims for bypass patients
Select NCH claims for bypass patients
(4)
All hospital inpatient and skilled nursing facility claims for bypass patients identified in (3)
(5)
All home health, outpatient, department, and physician/supplier claims for bypass patients identified in (3)
Construct episodes
(6)
Drop claims for services more than 30 days prior to the bypass admission. Divide remaining claims into 4 time frames
1) 30 days pre-admission
2) Inpatient bypass stay
3) 90 days post discharge
4) More than 90 days post discharge
If patient has multiple bypasses, the first counts as the index admission. Edit physician/supplier data to identify patients with more than $1,000 in allowed charges during the bypass inpatient stay.
Used in constructing home health, outpatient, SNF, other hospital inpatient, physician/supplier costs

had an angiogram in a demonstration hospital less than 72 hours before a bypass in the same facility, no extra billing for the diagnostic test was allowed.

During the study period a small number of CABG surgeries were also coded into DRG 108, which includes a variety of other cardiothoracic and vascular procedures. Although the same sets of procedure codes comprised DRG 106 and DRG 107 across all years of our study, DRG 108 underwent a major revision between 1990 and 1991. In 1990, DRG 108 was labeled "Other Cardiothoracic or Vascular Procedures With Pump" (St. Anthony Publications, 1990). This DRG was relabeled "Other Cardiothoracic Procedures" in the revised grouper effective October, 1990 (St. Anthony Publications, 1991), and the number of procedure codes in the DRG was reduced substantially. The change in the DRG definition substantially reduced the number of bypass patients coded into DRG 108 after 1990, because fewer patients undergoing bypass along with another procedure could be coded into this higher paying DRG. For all four years, CABG operations in DRG 108 were identified as observations having a CABG procedure code of 36.10, 36.11, 36.12, 36.13, 36.14, 36.15, or 36.19.

2.2.1.2 Data Editing

The data were checked and any duplicate or inconsistent cases were removed. In a few cases two claims appeared for the same beneficiary having CABG surgery in two different hospitals with the same admission and discharge dates. After examination of other fields on the record (primarily covered days and financial information), the erroneous case was identified and removed from the data. Next, hospital names and characteristics were merged onto the MedPAR records using data from the American Hospital Association file. A small number of hospitals could not be identified on the AHA file; for those hospitals we have no information on location, teaching status, or bedsize. As a result, these hospitals are not included in tables presented by such stratifications. Examination of the data indicated that a small number of hospitals appearing on the file were performing a very low number of cases. For example, the data included a psychiatric hospital performing six CABGs, and a 22-bed hospital performing only one. As a result, we removed from the file all observations for hospitals doing fewer than five CABGs per year, and those doing fewer than 20 if the AHA directory indicated that the hospital did not offer open heart surgery.

After these edits, we checked the CABG files for individuals having more than one bypass operation. In our national counts of bypass surgery, each bypass is counted, regardless of whether it is the first, second, or third for that individual occurring in our data. All bypasses are also included in calculating national breakdowns (such as by age of recipient),

and calculating length of stay, mortality rates, and inpatient hospital costs. However, in our estimates of costs per bypass recipient for the entire episode of care, costs were calculated at the beneficiary level rather than the bypass level. Thus, an individual receiving two bypasses would only count once, with the first bypass being the "index" admission, and future bypasses treated analogously to other inpatient stays.

2.2.1.3 Other Inpatient Stays

Our goal was to construct a person level utilization history, beginning 30 days prior to the admission for bypass surgery, and extending through 1993. After identifying all beneficiaries undergoing CABG surgery, we identified all other inpatient hospital and skilled nursing facility admissions for these individuals. Inpatient discharges occurring more than 30 days prior to the CABG admission were removed from the file.

2.2.2 National Claims History Data

The National Claims History (NCH) data contain a 100 percent sample of all Part B physician/supplier, outpatient department, home health, and hospice claims.

2.2.2.1 Selection Criteria

HCFA provided the evaluator with files containing all NCH claims for Medicare beneficiaries discharged from a hospital for CABG surgery during the period January, 1990 through September, 1993. The data were acquired in two phases: 1990-92 data and 1993 data. Our first round of data included all claims processed during 1990 through 1992 for bypass patients discharged during this three-year period. A second round of data included all claims for the last four months of 1992 and all of 1993 for patients discharged from the hospital for CABG surgery January through September 1993, as well as claims submitted in 1993 for patients having CABG during the last four months of 1992. The September, 1993, cutoff eliminated censoring in the 90-day post-discharge period, since all patients had at least 90 days post-discharge occurring in 1993.

2.2.2.2 File Construction

For each type of data--physician/supplier, outpatient department, and home health--our goal was to create a person-level file containing summary information from all of the individual claims. (Data from the hospice file were not processed since bypass patients should not be candidates for hospice care.) Date of admission, date of discharge, and provider number for the inpatient CABG stay were first merged on to each NCH claim. All claims for services provided more than thirty days before admission for the CABG surgery were discarded. The remaining claims were divided into four time frames:

(1) 30 days prior to admission;
(2) Inpatient CABG stay;
(3) 90 days post-discharge; and
(4) More than 90 days post-discharge.

Given the manner in which our data were extracted, data for the first three time periods should be complete for all bypass recipients, except those undergoing surgery in January, 1990. For the January, 1990, bypass recipients, the pre-admission data are truncated. The time frame covered by the period more than 90 days post-CABG varies considerably across the data, with the period being much longer for patients undergoing bypass in 1990 than for those treated in 1993. Thus, the truncation at different lengths post-discharge severely limits the inter-temporal comparisons that can be made for any extended period after bypass. Nevertheless, 90 days should capture much of the related follow-up care.

2.2.3 Prevalence of "Incomplete Claims"

In the construction of our patient-level files, the MedPAR data were considered the "gold standard" for identifying bypass patients. The MedPAR files required a minimal amount of data editing to remove duplicate or miscoded claims and should be complete in that they represent a 100 percent sample of inpatient hospital stays, and each bypass patient must have an inpatient stay. All other data were then merged onto the MedPAR records to create episodes of care for each patient. Many bypass patients had no SNF, outpatient department, or home health claims, or claims for hospital inpatient stays other than the bypass admission. We assumed that these other files were complete, and people with no claims in fact did not receive these services. We also found that some of the bypass patients appearing in the

MedPAR data had no physician/supplier claims. For example, in 1991, 10.6 percent of bypass patients on the MedPAR files had no physician/supplier claims. This degree of "incomplete" data can be attributed to patient membership in HMOs that do not submit Part B claims, to miscoded claims, and to claims that were erroneously not submitted. We also found that other patients had very few physician/supplier claims, and as a result, implausibly low allowed charges. In calculating average expenditures, we did not want to include these incomplete sets of claims in our analyses.

Thus, for all years, we restricted our physician/supplier analyses to patients with more than $1,000 in claims during the inpatient CABG stay. Again using 1991 as an example, this restriction eliminated another 2.4 percent of patients. Hence, our analysis of physician/supplier claims was based on 87 percent of the total bypass patients as reported in MedPAR.

2.2.4 Variable Construction

Data on national counts of Medicare bypass patients are based on the edited MedPAR files for 1990-93. Since the 1993 data contain bypasses only for patients discharged through September 30, annual totals are estimated by multiplying the January-September discharges by 1.33 (=1+3 missing/9 available months).

Mean values of three of our outcomes measures, mortality, length of stay, and hospital inpatient costs, differ by DRG. Thus, unadjusted hospital averages will reflect differences in the proportion of patients by DRG across hospitals. To eliminate this source of variation in tables presenting stratifications by hospital characteristics, mean values are adjusted for DRG mix. Mean values per hospital by DRG were calculated and weighted by the national proportion of cases in each DRG.

The charges presented in this chapter are all Medicare allowed charges. Thus, they represent expenditures incurred by the Medicare program and do not include deductibles or co-payments for which beneficiaries were responsible. Hospital inpatient charges include DRG base payments, outlier payments, disproportionate share payments, pass-throughs for capital related costs, bad debt, and direct medical education, and payments for indirect medical education. Allowed charges for types of care (physician/supplier, home health, and outpatient department) were calculated as 80 percent of total charges.

2.3 Trends and Distribution in Number of Cases and Hospitals

2.3.1 National Totals

Table 2-1 presents the number of hospitals performing CABG surgery on Medicare beneficiaries and the number of CABGs performed, for each of the four years in our study. In 1990, 833 hospitals, or roughly 15 percent of all short term acute care hospitals nationally, performed CABG surgery on Medicare beneficiaries. This number increased to 861 hospitals in 1991, to 880 hospitals in 1992, and to 906 hospitals in 1993, a nine percent increase across the four year period.

The total number of Medicare CABGs grew 16 percent between 1990 and 1992, from 129,270 to 150,027 in 1992. The number of CABGs then decreased by two percent to 147,139 in 1993. This decrease likely resulted from increases in the prevalence of less invasive coronary angioplasty (PTCA). Boutwell and Mitchell (1993) found that during the late 1980s bypass surgery grew by 37 percent among the Medicare population while angioplasty grew by 153 percent. As angioplasty continued to diffuse, and replaced bypass as the procedure of choice for many patients with one or two vessel disease, it has led to a reduction in the total number of bypasses performed.

The number of CABGs coded into DRG 108--other cardiothoracic or vascular procedures--dropped substantially, reflecting the change in coding that occurred during 1991. Excluding cases in DRG 108, the proportion of cases in DRG 106--CABG with cardiac catheterization--rose slightly from 57 percent of bypasses in 1990 to 60 percent in 1993. This indicates a slight increase in the proportion of patients undergoing angiography during the bypass stay, rather than prior to the bypass admission.

The vast majority of hospitals performing CABG surgery are found within urban (metropolitan statistical) areas. (Categories may not sum to the total number of hospitals because not all hospitals could be matched with AHA data.) While the number of rural (non-metropolitan) hospitals performing CABG surgery rose slightly between 1990 and 1993, from 35 to 41 hospitals, they still constitute fewer than five percent of the hospitals doing CABGs. It appears as if diffusion is nearly complete among the major teaching hospitals, but continued among other hospitals during our time frame.

As expected, small hospitals are unlikely to offer CABG surgery. The number of bypass hospitals with fewer than 200 beds performing CABG surgery never exceeds 100 in any year, despite the fact that more than 3,500 hospitals nationally belong in this size category (AHA, 1992). Larger hospitals are more likely to offer CABG surgery, consistent with the service being offered in urban and teaching hospitals. Roughly 80 percent of hospitals with 500 or

TABLE 2-1

NUMBER OF HOSPITALS PERFORMING MEDICARE BYPASSES, AND NUMBER OF MEDICARE BYPASSES PERFORMED, 1990-93

	1990			1991			1992			1993		
	Number of Hospitals	Number of Procedure	Percent of Procedures	Number of Hospitals	Number of Procedure	Percent of Procedures	Number of Hospitals	Number of Procedure	Percent of Procedures	Number of Hospitals	Number of Procedure	Percent of Procedures
NATIONAL	*833*	*129,270*		*861*	*139,448*		*880*	*150,027*		*906*	*147,139*	
DRG												
106		62,892	49%		79,013	57%		85,443	57%		84,362	57%
107		46,806	36		53,990	39		60,175	40		56,651	39
108		19,572	15		6,445	4		4,409	3		6,126	4
Location												
Urban	769	121,049	96	792	130,928	96	813	140,848	96	792	131,091	96
Rural	35	4,405	4	38	4,777	4	41	5,317	4	41	5,678	4
Teaching Status												
Major	223	47,335	38	223	49,558	37	225	52,734	36	209	47,762	35
Minor	223	37,601	30	231	40,542	30	236	43,512	30	240	42,113	31
None	358	40,518	32	376	45,605	33	393	49,919	34	384	46,894	34
Bedsize												
1 - 199 beds	84	6,851	5	87	7,403	5	95	8,163	5	96	8,291	6
200 - 299 beds	177	19,452	16	191	21,473	16	198	23,870	16	194	22,055	16
300 - 399 beds	195	24,399	19	202	26,710	20	207	28,860	20	214	29,337	21
400 - 499 beds	132	21,074	17	134	23,457	17	136	25,182	17	125	22,062	16
500 - 599 beds	92	20,059	16	91	21,678	16	92	22,837	16	87	20,317	15
600 - 699 beds	48	12,308	10	48	13,036	10	48	13,922	10	44	12,876	10
700 or more bed	76	21,311	17	77	21,948	16	78	23,321	16	73	21,831	16

NOTES

1 Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36 10-36 15 or 36 19

2 Categories may not sum to national total because hospitals could not be identified

3 Calendar year data 1993 values are annual estimates, based on discharges through September 30th

SOURCES 1990, 1991 1992, and 1993 MedPAR files and American Hospital Association files

more beds provided CABG surgery to Medicare patients during this period.

2.3.2 Volumes of Medicare CABGs Per Hospital

Table 2-2 presents the average number of Medicare CABGs (DRGs 106, 107, and 108) treated per hospital for 1990-93. The mean number rose from 155 in 1990 to 170 in 1992, and then decreased slightly to 162 in 1993. This decrease resulted from the two percent decrease in the total number of Medicare CABGs performed during 1993, coupled with the three percent increase in the number of hospitals offering CABG surgery. Given that approximately one half of all CABGs are performed on those age 65 and over (NCHS, 1990), this would imply that roughly 300 CABGs per year, or roughly six per week, were performed in the average hospital doing bypass surgery.

The inverted u-shape trend in average volumes holds for all classes when hospitals are stratified by location, teaching status, and bedsize categories. No stratification shown in Table 2-2 experienced a decline in the average number of cases treated between 1990 and 1991, or between 1991 and 1992. However, most stratifications experienced a decrease in the mean number of cases between 1992 and 1993.

Although the temporal trends are generally similar, there are noticeable differences in the mean number of Medicare cases treated across classes. For example, in all four years, the mean volume of cases treated in urban hospitals is roughly 30 percent larger than the mean volume in rural hospitals. Major teaching hospitals have higher mean volumes (4.4 bypasses per week) than minor teaching hospitals (3.3 bypasses per week), and substantially higher mean volumes than non-teaching hospitals (2.3 bypasses per week). Among the bedsize categories, the mean number of Medicare cases treated increases monotonically with bedsize, from roughly 1.6 per week in the smallest hospitals to 5.7 per week in the largest.

Table 2-3 presents percentile distributions for Medicare CABG volumes for each of the four years. Ten percent of hospitals doing CABG surgery (or roughly 80 hospitals) performed fewer than 40 Medicare CABGs annually, averaging less than one per week. Twenty five percent (roughly 200 hospitals) performed fewer than 70 annually (about 1.4 per week), and half the hospitals treated fewer than 130 Medicare CABG patients annually. In contrast, the ten percent of hospitals with the highest Medicare volumes performed more than 330 CABGs on Medicare patients annually (6.4 per week), and the top five percent performed more than 425 annually.

Substantial recent literature (much of which is summarized in Luft *et al.*, 1990) indicates a significant inverse relationship between volumes and outcomes for CABG surgery. That is,

TABLE 2-2

AVERAGE NUMBER OF MEDICARE BYPASSES TREATED PER HOSPITAL BY CHARACTERISTIC, 1990-93

	1990	1991	1992	1993
NATIONAL	*155*	*162*	*170*	*162*
Location				
Urban	157	165	173	165
Rural	126	126	130	136
Teaching Status				
Major	212	222	234	227
Minor	169	176	184	174
None	113	121	127	122
Bedsize				
1-199 beds	82	83	86	82
200-299 beds	110	112	121	113
300-399 beds	125	132	139	137
400-499 beds	160	175	185	174
500-599 beds	218	238	248	234
600-699 beds	256	272	290	293
700 or more beds	280	285	299	298

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are annual estimates, based on discharges through September 30th.

SOURCE: 1990, 1991, 1992, and 1993 MedPAR files.

TABLE 2-3

NATIONAL DISTRIBUTION THRESHOLDS OF MEDICARE BYPASS VOLUMES AMONG HOSPITALS PERFORMING BYPASS SURGERY, 1990-93

	PERCENTILES OF HOSPITALS							
National	Mean	5%	10%	25%	50%	75%	90%	95%
1990	155	22	34	64	120	203	333	427
1991	162	20	32	67	124	217	335	452
1992	170	23	36	69	130	229	363	454
1993	162	21	33	65	124	219	342	447

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are annual estimates, based on discharges through September 30th.

SOURCE: 1990, 1991, 1992, and 1993 MedPAR files.

hospitals performing higher volumes of CABGs tend to have better outcomes, ceteris paribus, than those with lower volumes. Thus, the substantial number of hospitals with low CABG volumes indicates that greater regionalization of the service would increase volumes per hospital and could reduce the frequency of poor outcomes nationally. Dayhoff and Cromwell (1994) estimated that mortality in the 90 days after bypass surgery could be reduced by roughly one percentage point (out of five) under greater regionalization.

2.4 Demographic Characteristics of Medicare Heart Patients

Although the number of Medicare CABGs has changed between 1990 and 1993, the proportion of beneficiaries by age categories, gender, and race have not varied substantially. The volumes of Medicare CABGs are shown in Table 2-4 by these breakdowns. As might be expected among Medicare beneficiaries, fewer than 10 percent of the recipients were under the age of 65. Patients between the ages of 65 and 74 received the majority of the Medicare CABGs performed. Roughly 35 percent are done on those between the ages of 65 and 69, and 31 percent are done on those between 70 and 74. Beyond age 74, the number of CABGs performed then begins to decrease with age. Approximately 6-7 percent of recipients are between 80 and 84 and only 1 percent are over 85 years of age. In all four years, the mean age of Medicare CABG recipients was just over 70 years.

Twice as many men as women underwent CABG surgery in 1990, a ratio that did not change noticeably over time. Greater prevalence of coronary artery disease among men no doubt plays a substantial role in this discrepancy, although females are poorer candidates for surgery due to their smaller arteries.

An overwhelming 92 percent of the procedures were performed on whites during 1990, a figure that decreased by only two percentage points by 1993. Nationally, whites constitute slightly less than 90 percent of the population age 65 and older (Statistical Abstract, 1992). Conversely, only 3 percent of surgeries were on blacks, 2-3 percent on other known race/ethnicities, and another 3 percent on people whose race was unknown or not recorded. Ford *et al.* (1989) and Oberman and Cutter (1984) concluded that racial differences in CABG rates are unrelated to racial differences in the rates of coronary artery disease. Ayanian *et al.* (1993) found that rates of bypass and angioplasty following angiography were lower for blacks than whites, while Boutwell and Mitchell (1993) found that rural residents do not have significantly different bypass rates than urban residents. These studies cast doubts on the plausibility of differences being due solely by differences in geographic access to hospitals offering bypass surgery. Other explanations for the racial differences in CABG rates include a

TABLE 2-4

NATIONAL NUMBER OF MEDICARE BYPASS OPERATIONS BY AGE, GENDER, AND RACE, 1990-93

	BYPASS PROCEDURES							
	1990		1991		1992		1993	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Age								
Under 65 years	10,641	8 %	10,852	8 %	11,594	8 %	11,709	8 %
65 - 69 years	45,289	35	46,896	34	49,091	33	47,778	33
70 - 74 years	39,696	31	43,463	31	47,055	31	45,709	31
75 - 79 years	24,807	19	27,719	20	30,298	20	30,000	20
80 - 84 years	7,564	6	9,029	6	10,179	7	10,108	7
85 years and older	1,273	1	1,489	1	1,810	1	1,834	1
Gender								
Male	87,445	68	93,256	67	100,250	67	97,722	66
Female	41,825	32	46,192	33	49,750	33	49,418	34
Race								
Unknown	3,846	3	4,372	3	4,967	3	5,062	3
White	118,842	92	127,373	91	136,243	91	132,674	90
Black	4,112	3	4,534	3	5,070	3	5,200	4
Other	2,470	2	3,168	2	3,669	2	4,203	3

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are annual estimates based on discharges through September 30th.

SOURCE: 1990, 1991, 1992 and 1993 MedPAR files.

greater reluctance among blacks to have surgery, physician racial prejudice, or lack of Medicare supplemental insurance.

2.5 Trends in National Mortality

The MedPAR files contain a field indicating whether each admission ended in a live discharge or death of the patient. Although in-hospital mortality rates measure only one aspect of the patient's outcome, they do provide a useful benchmark for cross-sectional and intertemporal comparisons of outcomes from surgery. Table 2-5 presents average in-hospital mortality rates for hospitals treating Medicare CABG patients. Mortality rates are adjusted to standardize the proportion of patients in each DRG. The average mortality rate decreased substantially from 6.5 percent in 1990, to 5.3 percent in 1992, before increasing slightly to 5.5 percent in 1993. This trend in mortality rates is also apparent for most stratifications.

Within any year, mortality rates vary noticeably by hospital characteristic. The urban mortality rate is higher than the rural rate in each year, major teaching hospitals have a higher mortality rate on average than minor teaching hospitals, and larger hospitals tend to have lower mortality rates than their smaller counterparts. However, with no further adjustments for case-mix severity, it is difficult to interpret these results. For example, higher mortality rates among major teaching hospitals could be caused by more severely ill patients being referred to these facilities. Lower mortality rates among larger hospitals could be due either to a less severe casemix, or more likely, from greater familiarity with the procedure.

The variation in hospital mortality rates is even more apparent in Table 2-6. For example, in 1990, ten percent of hospitals doing CABG surgery had mortality rates for Medicare beneficiaries of 2.6 percent or less. Another ten percent had mortality rates of 11.1 percent or higher. Again, these variations are difficult to assess without information on casemix severity. Random variation also plays a role, especially in smaller hospitals. The general downward trend in mortality across time is also seen in the percentile distributions between 1990 and 1992. At each percentile threshold, the mortality rate decreased between 1990 and 1991, and then again between 1991 and 1992. Between 1992 and 1993, the lower percentiles all continued to experience decreases in mortality rates, while the higher percentiles all experienced increases, indicating greater variation in mortality rates across hospitals in 1993.

TABLE 2-5

IN-HOSPITAL MORTALITY RATES FOR HOSPITALS TREATING MEDICARE BYPASS PATIENTS, 1990-93

	1990	1991	1992	1993
National	6.5 %	5.7 %	5.3 %	5.5 %
Location				
Urban	6.6	5.7	5.3	5.5
Rural	4.8	5.3	4.5	4.9
Teaching Status				
Major	6.8	5.8	5.8	5.4
Minor	6.0	5.6	5.0	5.1
None	6.6	5.5	5.1	5.7
Bedsize				
1-199 beds	8.0	6.8	5.5	6.7
200-299 beds	6.3	5.6	5.2	5.5
300-399 beds	6.4	5.9	5.4	5.6
400-499 beds	6.3	5.1	5.4	5.1
500-599 beds	6.0	5.3	5.2	5.5
600-699 beds	6.2	4.7	4.5	4.4
700 or more beds	6.5	5.8	5.0	4.7

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th.
3. Adjusted to standardize proportion of patients in each DRG within each year.

SOURCE: 1990, 1991, 1992, and 1993 MedPAR files.

TABLE 2-6

NATIONAL DISTRIBUTION THRESHOLDS OF MEDICARE HOSPITAL BYPASS MORTALITY RATES, 1990-93

	PERCENTILES OF HOSPITALS							
	Mean	5%	10%	25%	50%	75%	90%	95%
National								
1990	6.5 %	1.8 %	2.6 %	4.0 %	5.9 %	8.2 %	11.1 %	13.3 %
1991	5.7	1.7	2.3	3.4	4.9	6.8	9.6	12.0
1992	5.3	1.6	2.2	3.2	4.6	6.6	9.0	10.6
1993	5.5	1.4	2.0	3.0	4.7	6.9	9.5	11.3

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th.
3. Adjusted to standardize proportion of patients in each DRG within each year.

SOURCE: 1990, 1991, 1992 and 1993 MedPAR files.

2.6 Trends in Bypass Lengths of Stay by DRG and Hospital Type

Average length of stay represents a second outcome measure that can be used to compare hospitals. Table 2-7 presents trends in average lengths of stay per hospital standardized to the national proportion of cases in each DRG. The national trend has been towards shorter stays, from an average of 15.0 days in 1990 to 12.5 days in 1993. This downward trend is also seen for all stratifications shown in the table. The average length of stay for each of the three CABG DRGs decreased between 1990 and 1993, as did the average stay for each hospital grouping.

Average lengths of stay differ noticeably across the three DRGs, as expected. DRG 108, including CABG patients who also underwent other thoracic or vascular procedures, had the longest average stay, ranging from 17.9 days in 1990 down to 14.4 days in 1993. CABG with cardiac catheterization on the same admission (DRG 106) required a stay roughly 3 days longer than CABG without cardiac catheterization (DRG 107) in each of the four years.

Like mortality rates, average lengths of stay remain unadjusted for casemix severity. Although we adjust for differences in the proportion of CABGs falling into each of the three DRGs, other differences in severity of illness may account for the longer stays at major teaching hospitals and at larger hospitals generally.

Table 2-8 presents distribution statistics for average lengths of stay per hospital. These percentile thresholds again indicate the decreasing lengths of stay over the four year period. For instance, in 1990, five percent of hospitals had stays of 11.0 or fewer days even after controlling for DRG mix. By 1993, five percent had stays of 9.4 or fewer days. All three years show substantial variation in length of stay across hospitals. The difference in average stays between the top and bottom ten percent of all hospitals was roughly seven days in 1990, narrowing to just under six days in 1993. Differences of this magnitude can add thousands of dollars to the average patient's cost.

2.7 Trends in Expenditures by Type and Locus of Service

By combining the MedPAR and NCH data, we can present data on expenditures by type of service, location of service, and timing of service relative to when the heart bypass surgery was performed. We first present summary data on trends in expenditures across our four time frames: (1) 30 days prior to admission, (2) inpatient stay, (3) 90 days after the bypass, and (4) more than 90 days later. We then present more detailed breakdowns on expenditures during the time frames.

TABLE 2-7

AVERAGE LENGTH OF STAY FOR MEDICARE BYPASS PATIENTS, 1990-93

	1990	1991	1992	1993
NATIONAL	*15.0 Days*	*14.0 Days*	*13.5 Days*	*12.5 Days*
DRG				
DRG 106	15.7	15.2	14.6	13.7
DRG 107	12.2	11.5	11.2	10.5
DRG 108	17.9	15.3	15.3	14.4
Location				
Urban	14.9	14.0	13.4	12.5
Rural	14.2	13.6	13.1	12.5
Teaching Status				
Major	16.5	15.3	14.6	13.7
Minor	14.5	13.7	13.2	12.2
None	14.1	13.3	12.8	12.0
Bedsize				
1-199 beds	14.1	13.2	13.0	12.1
200-299 beds	14.0	13.4	13.0	12.0
300-399 beds	14.7	13.6	13.0	12.1
400-499 beds	15.1	14.5	13.7	13.0
500-599 beds	15.7	14.3	13.7	12.9
600-699 beds	15.6	14.2	13.5	12.8
700 or more beds	16.6	15.8	14.8	13.9

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19
2. Calendar year data, 1993 values are based on discharges through September 30th.
3. Adjusted to standardize proportion of patients in each DRG within each year.

SOURCE: 1990, 1991, and 1992 MedPAR files.

TABLE 2-8

NATIONAL DISTRIBUTIONS OF MEDICARE BYPASS LENGTH OF STAY PER HOSPITAL, 1990-93

		PERCENTILES						
	Mean	5%	10%	25%	50%	75%	90%	95%
National								
1990	15.0	11.0	11.7	13.0	14.5	16.5	18.6	20.2
1991	14.0	10.5	11.1	12.1	13.7	15.4	17.0	18.3
1992	13.5	9.9	10.6	11.7	13.1	14.8	16.4	17.9
1993	12.5	9.3	9.8	10.9	12.2	13.7	15.5	16.9

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th.
3. Adjusted to standardize proportion of patients in each DRG within each year.

SOURCE: 1990, 1991, 1992 and 1993 MedPAR files.

2.7.1 Aggregate Trends in Charges

Table 2-9 presents average Medicare program allowed charges (or payments) per Medicare bypass patient by time period and type of service. Program charges during the 30 days prior to admission for the bypass ranged from $2,532 to $2,771 across the four years. The majority of this amount was comprised of Part A expenditures for hospital inpatient stays prior to the admission for bypass surgery. These could be previous admissions for heart problems, previous admissions for angiography (for patients in DRG 107), or unrelated admissions that occurred in the 30 days prior to the admission for bypass. Outpatient department spending accounted for 8-9 percent of the total, while home health and skilled nursing facility charges combined contributed less than one percent to total spending. Part B payments to physicians and suppliers constituted just over one third of the total expenditures during the pre-bypass period, although this proportion decreased between 1990 and 1993. This decrease in physician spending is consistent with the introduction of the Medicare. Fee Schedule, phased in beginning January 1, 1992, that restructured payments to physicians. Under the resource based relative value scale (RBRVS), Medicare payments to specialists for procedures were generally reduced, while payments to primary care physicians for management were generally increased. Thus, we would expect lower physician payments for care of bypass patients.

Part A payments plus Part B allowed charges during the bypass inpatient stay ranged from $29,434 in 1990 to $30,905 in 1993, a five percent increase. The proportion of charges accounted for by hospital Part A payments rose from 71 to 82 percent of the total, while physician/supplier payments decreased after 1991, concurrent with the introduction of the Medicare Fee Schedule.

Charges for the 90 days following discharge after bypass surgery rose by 20 percent from 1990 to 1993. In each year the majority of spending (53-60 percent) was for other hospital inpatient stays. These were patients readmitted to a hospital during the 90-day window. Physician/supplier expenditures decreased during the period while outpatient department expenditures rose slightly (although the proportion of total spending fell). Average home health spending rose by 80 percent from 1990 to 1993, while average skilled nursing facility spending rose by more than 100 percent. Despite this rapid growth, these two sources of expenditures still combined for only 17.6 percent of all spending in 1993, up from 12 percent four years earlier. This rise in skilled nursing and home health expenditures is consistent with shorter lengths of stay observed during the period, implying that patients require more care once they are discharged from the hospital.

Data for the period more than 90 days after bypass are difficult to assess. The length of

TABLE 2-9

AVERAGE PART A PAYMENTS AND PART B ALLOWED CHARGES FOR MEDICARE HEART BYPASS PATIENTS, 1990-93

	1990		1991		1992		1993	
	Average Allowed Charges	Proportion of Category	Average Allowed Charges	Proportion of Category	Average Allowed Charges	Proportion of Category	Average Allowed Charges	Proportion of Category
30 Days Prior to Bypass Admission								
Hospital Inpatient	$1,371	54.1 %	$1,469	55.1 %	$1,544	55.7 %	$1,503	56.8 %
Physician/Supplier	932	36.8	960	36.0	1,001	36.1	886	33.5
Outpatient Department	222	8.8	226	8.5	214	7.7	236	8.9
Home Health	7	0.3	10	0.4	11	0.4	16	0.6
Skilled Nursing Facility	1	0.0	1	0.0	1	0.1	3	0.1
TOTAL	2,532	100.0	2,665	100.0	2,771	100.0	2,644	100.0
Bypass Inpatient Stay								
Hospital Inpatient	23,258	79.0	23,463	77.8	24,928	79.8	25,373	82.1
Physician/Supplier	6,176	21.0	6,706	22.2	6,298	20.2	5,532	17.9
TOTAL	29,434	100.0	30,169	100.0	31,226	100.0	30,905	100.0
90 Days After Bypass Discharge								
Hospital Inpatient	1,698	58.4	1,838	55.8	1,976	60.0	2,170	56.5
Physician/Supplier	673	23.1	798	24.2	822	25.0	788	20.5
Outpatient Department	192	6.6	204	6.2	183	5.5	209	5.4
Home Health	287	9.9	375	11.4	367	11.1	518	13.5
Skilled Nursing Facility	60	2.1	78	2.4	118	3.6	159	4.1
TOTAL	2,910	100.0	3,293	100.0	3,466	100.0	3,844	100.0
BYPASS EPISODE TOTAL	34,876		36,127		37,463		37,393	
More than 90 Days After Bypass Discharge (see Note 5)								
Hospital Inpatient	6,228	55.4	4,859	57.5	3,049	69.0	1,125	48.6
Physician/Supplier	3,226	28.7	2,432	28.8	951	21.5	798	34.5
Outpatient Department	1,195	10.6	726	8.6	235	5.3	229	9.9
Home Health	394	3.5	287	3.4	91	2.1	125	5.4
Skilled Nursing Facility	199	1.8	150	1.8	94	2.1	37	1.6
TOTAL	11,242	100.0	8,455	100.0	4,420	100.0	2,314	100.0

NOTES.

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th.
3. Hospital inpatient for the Bypass Inpatient stay includes the admission for bypass surgery. Hospital inpatient for the other time frames includes other hospital stays.
4. Physician/supplier data are based on patients with more than $1,000 of physician/supplier allowed charges during the bypass inpatient stay.
5. The "more than 90 days after bypass" data include allowed charges through 1993. Thus, the length of time varies with the year in which the bypass was performed, and, hence, are not comparable across time. 1990 data report average payments for almost three years post-discharge while 1993 data report only nine months at most.
6. Medicare program expenditures. Excludes patient liability.

SOURCE. 1990-1993 MedPAR and National Claims History files.

follow-up varies considerably according to when the bypass was performed. The total value of $11,242 for patients undergoing bypass in 1990 reflects allowed charges during a period of more than three years. In contrast, the total of $2,314 for patients undergoing bypass in 1993 reflects allowed charges for a period of less than one year. In addition to the truncation problem, spending during the longer time frame is likely to be confounded by other illnesses that are unrelated to the heart bypass. However, for all four years, the highest expenditures are for Part A hospital inpatient stays, followed by physician/supplier spending.

Table 2-10 presents total Medicare program expenditures on bypass surgery, calculated as the per-person expenditures multiplied by the number of Medicare bypass recipients. Total expenditures from 30 days pre-admission to 90 days post discharge grew 24 percent between 1990 and 1992, from $4.5 billion to $5.6 billion. This increase resulted from the 16 percent increase in bypasses performed coupled with the seven percent increase in costs per bypass. Total expenditures then dropped slightly to $5.5 billion in 1993, as a result of the slight declines in bypasses performed and costs per bypass.

Expenditures during the inpatient stay accounted for the majority of the total costs in every year (roughly 80 percent). However, the fastest growing costs were for the period after discharge, which rose 50 percent, from $376 million in 1990 to $566 million in 1993. This is consistent with the change in expenditures by locus of care, with home health costs more than doubling, from $38 to $78 million, and skilled nursing facility expenditures more than tripling, from $8 to $24 million. Thus, while prospective payment and the fee schedule were geared toward keeping hospital and physician costs in check, home health and SNF care costs exploded.

Tables 2-9 and 2-10 present highly aggregated summary data. More detailed expenditure breakdowns that follow shed light on the trends. For example, skilled nursing facility charges are quite low for all periods. What proportion of patients incur any SNF charges? How are physician/supplier inpatient expenditures spread across different physician specialties?

2.7.2 Charges Incurred Prior to the Bypass

Table 2-11 presents a more detailed breakdown of charges incurred by heart bypass patients during the 30 days prior to admission for the bypass surgery. Almost 38 percent of all bypass patients experienced another inpatient hospital stay within the 30 days prior to the bypass admission. This proportion is much higher for patients in DRG 107 (not shown), reflecting admissions for angiography prior to the admission for bypass surgery. Inpatient

Table 2-10

TOTAL MEDICARE PROGRAM EXPENDITURES ON BYPASS SURGERY, 1990-93

	1990	1991	1992	1993	Percent Change 1990-93
By timing of expenditure					
30 Days Prior to Bypass Admission	$327,440,910	$371,768,368	$415,724,817	$389,035,516	18.8 %
Bypass Inpatient Stay	3,804,933,180	4,207,006,712	4,684,743,102	4,547,330,795	19.5
90 days After Bypass Discharge	376,175,700	459,202,264	519,993,582	565,602,316	50.4
Total Bypass Episode	4,508,549,790	5,037,977,344	5,620,461,501	5,501,968,627	22.0
By Locus of Care					
Hospital Inpatient	3,403,291,290	3,733,022,960	4,267,968,096	4,273,799,394	25.6
Physician/Supplier	1,005,849,870	1,180,287,872	1,218,369,267	1,060,283,634	5.4
Outpatient Department	53,517,780	59,962,640	59,560,719	65,476,855	22.3
Home Health	38,005,380	53,687,480	56,710,206	78,572,226	106.7
Skilled Nursing Facility	7,885,470	11,016,392	17,853,213	23,836,518	202.3
Total Bypass Episode	4,508,549,790	5,037,977,344	5,620,461,501	5,501,968,627	22.0

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG106 or DRG107 and cases in DRG108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are annual estimates based on discharges through September 30.
3 Medicare program expenditures. Excludes patient liability.

SOURCE: 1990-93 MedPAR and NCH files.

TABLE 2-11

AVERAGE PART A PAYMENTS AND PART B ALLOWED CHARGES FOR MEDICARE HEART BYPASS PATIENTS, 30 DAYS PRIOR TO ADMISSION, 1990-93

	Percent of Patients wit claims	1990	1991	1992	1993
Hospital Inpatient	37.9 %	$1,371	$1,469	$1,544	$1,503
Skilled Nursing Facility	0.1	0.60	1.05	1.49	2.56
Home Health					
Skilled Nursing	1.4	4.70	6.52	7.45	10.73
Aides	0.5	1.31	1.91	2.25	3.59
Physical Therapy	0.2	0.43	0.59	0.50	1.03
Supplies	0.4	0.07	0.23	0.15	0.27
Other	0.2	0.23	0.33	0.38	0.51
Total	1.6	6.73	9.68	10.73	16.12
Outpatient Department					
Cardiology	12.6	78.62	82.14	80.66	86.83
Radiology	16.6	38.36	38.09	33.42	38.21
Supplies	12.7	22.95	24.64	23.19	23.71
Lab	19.0	16.02	15.84	15.64	18.07
Pharmacy	13.4	15.07	16.22	16.47	18.24
EKG	12.2	7.88	6.84	6.08	6.78
Clinic	6.4	4.85	4.85	3.92	4.48
Operating Room	1.0	3.70	2.95	2.75	3.49
Anesthesia	0.5	0.47	0.44	0.36	0.39
Therapy	0.3	0.50	0.40	0.50	0.71
Cardiac Rehabilitation	0.3	0.38	0.30	0.26	0.35
Dialysis	0.4	3.24	3.63	3.94	4.39
Other	13.5	29.63	29.27	26.43	30.81
Total	30.3	221.67	226.63	213.61	236.45
Physician/Supplier					
Office	71.3	130.99	149.65	174.41	159.75
Hospital	55.3	656.30	641.54	627.23	527.74
Outpatient Department	54.5	103.57	124.46	143.81	140.23
Lab	15.9	9.42	10.13	11.69	11.47
Skilled Nursing Facility	0.2	0.31	0.15	0.18	0.20
Other	13.2	31.62	33.97	43.99	46.87
Total	89.5	932.20	969.90	1,001.32	886.25
TOTAL PRE-BYPASS		2,532	2,665	2,771	2,644

NOTES

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19
2. Calendar year data. 1993 values are based on discharges through September 30th
3. Hospital inpatient includes allowed charges for stays prior to the admission for bypass surgery
4. Physician/supplier data are based on patients with more than $1,000 of physician/supplier allowed charges during the bypass inpatient stay
5. Medicare program expenditures. Excludes patient liability.

SOURCE: 1990, 1991, 1992 and 1993 MedPAR and National Claims History Data

stay costs calculated only for those with a prior admission averaged roughly $4,000 versus roughly $1,500 across all patients. In contrast, only 0.1 percent experienced a stay at a skilled nursing facility during this same period, accounting for the low average charges. The proportion of patients utilizing any prior home health care is also quite small, explaining the low average charges for this type of service.

Outpatient department allowed charges varied from $213.61 to $236.45 across the four years, with roughly 30 percent of patients incurring outpatient costs. The hospital revenue center with the highest average allowed charges is cardiology, accounting for roughly 35 percent of the total charges, followed by radiology, supplies, lab, and pharmacy. These five revenue centers combine to account for roughly 75 percent of total charges in each year.

Part B physician/supplier charges reflect noticeable shifts in location of service across our time frame. Charges for hospital care prior to the CABG admission have decreased by 20 percent, although they still constitute the majority of total physician/supplier charges. In contrast, both average office charges and outpatient department charges have increased by more than 20 percent from 1990 to 1993. This shift would be consistent with a change in site of care; although the proportion of patients receiving services in these settings did not vary substantially across the four years, the intensity of services received could have varied. Alternatively, introduction of the Medicare Fee Schedule in 1992 would tend to cause a shift in this direction, as payments for hospital- based procedures declined while those for office based management activities increased.

2.7.3 Charges During the Inpatient Stay

Table 2-12 presents detailed average charges during the inpatient bypass stay. The first column again gives the average number of patients with claims for each classification. By design, all patients in our sample have Part A inpatient CABG claims. All patients should also have claims for both anesthesia during surgery and at least one surgeon's bill. Our data indicate that 96 percent of patients have an anesthesiologist's or nurse anesthetist's bill. The missing four percent could be attributed to miscoding of specialty on the claims, or missing data despite our data trims. Eighty two percent of patients had a cardiothoracic surgeon's bill. The bypass procedure codes were also coded by physicians identified with a specialty of general surgery or cardiology.

In addition to claims for anesthesia and surgery, bypass patients would be expected to have claims for other medical specialists. For example, patients in DRG 106, who are undergoing cardiac catheterization during the bypass stay, would have cardiology claims, as

TABLE 2-12

AVERAGE PART A PAYMENTS AND PART B ALLOWED INPATIENT CHARGES FOR MEDICARE HEART BYPASS PATIENTS, 1990-93

	Percent of Patients with claims	1990	1991	1992	1993
Hospital Inpatient Services	100.0 %	$23,258	$23,463	$24,928	$25,373
Physician/Supplier Services					
Anesthesia	95.7	816	982	973	853
Cardiology	83.3	1,252	1,405	1,206	1,036
Cardiothoracic Surgery	81.9	2,739	2,869	2,847	2,560
Radiology	91.4	125	138	132	112
Pulmonology	19.8	78	86	85	83
Other Physicians	74.3	850	853	740	622
Non-Physicians	45.1	317	375	315	266
Total	100.0	6,176	6,706	6,298	5,532
TOTAL INPATIENT		29,434	30,169	31,226	30,905

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th.
3. Physician/supplier data are based on patients with more than $1,000 of physician/supplier allowed charges during the bypass inpatient stay.
4. Anesthesia includes both anesthesiologists and certified registered nurse anesthetists.
5. Medicare program expenditures. Excludes patient liability.

SOURCE: 1990, 1991, 1992 and 1993 MedPAR and National Claims History Data.

would most patients in DRG 107. Most patients would also be expected to have claims for radiology during the bypass stay. Patients would then have claims for other medical specialists in accordance with treatment for co-morbid conditions or complications. For example, 19.8 percent of patients were treated by pulmonologists. Almost 75 percent of Medicare bypass recipients received treatment from other physician specialties, such as nephrology, internal medicine, or neurology. Additionally, 45 percent of bypass patients had claims from non-physician suppliers who are allowed to bill independently, such as physical or occupational therapists, psychologists, and clinical social workers

Physician/supplier expenditures decreased from 21.0 percent of total inpatient expenditures in 1990 to 17.9 percent in 1993, as hospital spending increased while physician spending fell. Cardiothoracic surgeons received roughly 45 percent of the payments to physicians in each year, cardiologists roughly 21 percent, and anesthesiologists roughly 15 percent. The effects of physician payment reform are evident, as specialties experienced decreased allowed charges between 1991 and 1993. Different update rates in allowable fees under the Medicare Fee Schedule due to the volume performance standards imply higher surgery fees after 1993 relative to other specialties.

The MedPAR files include information on federal Part A reimbursement for each inpatient hospitalization. Under prospective payment, hospitals are reimbursed a fixed amount per case based on the DRG in which the patient is classified, regardless of the costs incurred. Thus, one source of variation in payments to the hospitals is the variation in the proportion of patients falling into each of the three CABG DRGs (106, 107, and 108). Payments to hospitals also vary because of pass-through amounts including capital related costs, direct medical education, and bad debts, as well as separate payment amounts for indirect medical education, and patients exceeding the outlier thresholds.

The average total expenditure per patient for each hospital performing Medicare CABGs is presented in Table 2-13, adjusted by the proportion of patients in each DRG, using the same stratifications presented earlier in the chapter. In each year, the average urban hospital received a Medicare payment roughly $5,000 more per CABG than its rural counterpart, a difference of roughly 25 percent. Minor teaching hospitals received slightly higher payments on average than non-teaching hospitals, and both received about two thirds of the amount paid a major teaching hospital. Payments increase on average with bedsize, with the largest hospitals receiving roughly $8,000 more per year than the smallest. These variations are consistent with variations in pass-through amounts, as well as the urban, teaching orientation of larger hospitals.

TABLE 2-13

AVERAGE MEDICARE PART A EXPENDITURES FOR BYPASS HOSPITALIZATION, 1990-93

	1990	1991	1992	1993
National	*$23,258*	*$23,463*	*$24,928*	*$25,373*
Location				
Urban	23,589	23,748	25,213	25,510
Rural	18,014	18,877	20,491	20,904
Teaching Status				
Major	29,818	30,016	32,916	33,801
Minor	21,252	21,724	22,670	22,909
None	20,620	20,781	21,837	22,098
Bedsize				
1-199 beds	21,549	21,476	22,929	23,392
200-299 beds	21,049	21,506	22,624	22,695
300-399 beds	23,098	22,992	24,156	24,537
400-499 beds	23,406	23,838	25,440	25,959
500-599 beds	24,679	24,949	27,153	28,095
600-699 beds	24,182	24,244	23,814	26,156
700 or more beds	29,078	29,565	31,831	31,738

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th.
3. Adjusted to standardize proportion of cases in each DRG.
4. Medicare program expenditures. Excludes patient liability.

SOURCE: 1990, 1991, 1992, and 1993 MedPAR files.

2.7.4 Charges Following the Bypass

Table 2-14 presents data on allowed charges during the 90-day period following discharge from the hospital for bypass surgery. Total expenditures during this period rose 32 percent, from $2,910 in 1990 to $3,844 in 1993.

The patient's post-discharge pattern of care can take several forms. Patients who do well after discharge may receive only routine outpatient and physician care. Patients who are in frailer condition may be discharged to a SNF or receive home health care, dependent on the level of care needed, with resulting higher incurred charges. Some patients will be discharged, only to require readmission for a complication such as post-surgical infection. These patients will incur Part A charges for the additional hospital stay as well as Part B charges for their physician care.

Roughly one quarter of all bypass patients had another inpatient stay within 90 days of the bypass stay. This total would include a small number of patients readmitted for more bypass surgery, patients with continuing heart problems, or any other admission within this time frame. Inpatient hospital stays accounted for over half the expenditures during the post-surgery period. Spending on post-bypass inpatient hospital stays rose by 27 percent from 1990 to 1993 ($1,698 to $2,170); in contrast the cost of the CABG inpatient stay rose by only 9 percent. The proportion of patients re-admitted within 90 days after the bypass rose only slightly (23.5 percent to 24.7 percent, now shown) during the four year period, so an increase in patients requiring further hospitalization did not account for the large increase in spending. Higher readmission costs could imply that shortened lengths of stay are resulting in readmissions for more serious conditions, although we can draw no definitive conclusions from our data.

The average amount spent on skilled nursing facility stays more than doubled during this period, from $60 to $159. This accounted for 11 percent of the growth in allowed charges during the post-bypass period. The increase in average charges resulted from increased utilization of SNFs after discharge (from 2.1 percent of patients in 1990 to 3.9 percent in 1993, not shown). Again, this increase may result from shorter inpatient hospital stays, necessitating continued treatment at a SNF.

Average home health charges rose from $287 to $518 (roughly 80 percent) between 1990 and 1993, although the proportion of patients with home health claims increased only slightly. This implies a greater intensity of care, i.e., more skilled nursing visits per patient, among those receiving home health care. As in the pre-surgery period, the bulk of spending was on skilled nursing care.

Average outpatient department charges rose from $192 in 1990 to $209 in 1993.

TABLE 2-14

AVERAGE PART A PAYMENTS AND PART B ALLOWED CHARGES FOR MEDICARE HEART BYPASS PATIENTS DURING THE 90 DAYS AFTER BYPASS SURGERY, 1990-93

	Percent of Patients with claims	1990	1991	1992	1993
Hospital Inpatient	24.1 %	$1,698	$1,838	$1,976	$2,170
Skilled Nursing Facility	2.9	60	78	118	159
Home Health					
Skilled Nursing	26.1	204	261	254	355
Aides	9.6	51	70	68	97
Physical Therapy	4.9	16	23	24	37
Supplies	9.8	7	8	8	12
Other	4.2	9	12	12	17
Total	26.3	287	375	367	618
Outpatient Department					
Cardiology	7.6	14	12	10	12
Radiology	23.5	35	33	28	31
Supplies	10.4	6	7	6	8
Lab	30.3	26	27	25	29
Pharmacy	9.2	5	5	5	6
EKG	13.1	11	9	7	9
Operating Room	1.4	4	4	4	4
Anesthesia	0.6	1	1	1	1
Therapy	1.7	10	10	9	9
Cardiac Rehabilitation	10.0	29	45	37	44
Clinic	13.6	10	10	10	11
Dialysis	0.6	19	21	20	22
Other	9.9	22	20	19	24
Total	46.6	192	204	183	209
Physician/Supplier					
Office	86.3	213	263	278	262
Hospital	27.7	333	379	371	353
Outpatient Department	44.6	55	66	68	65
Lab	33.9	21	28	21	29
Skilled Nursing Facility	2.1	3	3	4	5
Other	18.4	49	59	70	74
Total	94.6	674	798	822	788
TOTAL POST BYPASS		2,910	3,293	3,466	3,844

NOTES

1 Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19

2 Calendar year data. 1993 values are based on discharges through September 30th

3 Hospital inpatient includes allowed charges for stays after the discharge for bypass surgery

4 Physician/supplier data are based on patients with more than $1,000 of physician/supplier allowed charges during the bypass inpatient stay.

5 Medicare program expenditures. Excludes patient liability

SOURCE: 1990-93 MedPAR and National Claims History files

Several areas actually experienced declining average charges across time. For example, less was spent on both cardiology and radiology on average in 1993 than in 1990. In contrast, spending on cardiac rehabilitation rose by 50 percent during our time frame, making it the single largest hospital-based expenditure category for the years 1991-93. The increase in spending on cardiac rehabilitation accounted for almost all the (minor) increase in outpatient department spending across the four years. This increase was accompanied by only a nine percent increase in the fraction of patients receiving cardiac rehabilitation, again implying more intensive care for those receiving the service.

Part B expenditures mirrored those found during the CABG inpatient stay; declining across the period, with the largest decrease between 1990 and 1991. The largest amount in each year was for hospital treatment following the bypass, followed by office visits.

2.7.5 Multivariate Analysis of Expenditures

Table 2-13 indicated that payments to hospitals for the bypass stay varied considerably according to hospital characteristic. To further explore reasons for variation in costs per bypass, Table 2-15 presents three sets of multivariate linear regression results. The dependent variables for the three regressions are: (1) hospital Part A inpatient reimbursement for the bypass stay; (2) hospital and physician/supplier reimbursement for the bypass stay; and (3) total reimbursement for the bypass episode, from 30 days pre-admission to 90 days post-discharge. Each regression uses the same set of independent variables: characteristics of the bypass hospital (urban/rural location, teaching status, bedsize); characteristics of the patient (age, gender, race); the patient's DRG; year of discharge; and patient discharge status. Left-out referent groups that are reflected in the intercept are listed in parentheses.

The variables with the largest coefficients in all three regressions are the teaching status dummies. Payments for the inpatient hospital stay to non-teaching hospitals and minor teaching hospitals are roughly $9,100 lower and $7,600 lower than to major teaching hospitals, ceteris paribus. Teaching status has an even larger effect on payments during the entire bypass episode, column 3 accounting for roughly $18,880 and $16,600 of the variation in charges, respectively. This result is explained if patients with readmissions return to the hospital in which the bypass was performed. Each stay in the teaching hospital would be more expensive than in the non-teaching hospital, so additional stays would increase the overall teaching differential for the episode.

The variables with the next largest coefficients are the DRG dummies, with both DRG 106 and DRG 107 receiving lower payments than DRG 108. It is surprising that the differential

TABLE 2-15

EXPENDITURE REGRESSIONS FOR MEDICARE BYPASS PATIENTS, 1990-93

	Hospital Inpatient Reimbursement	Hospital & Physician/supplier Inpatient Reimbursement	Total Bypass Episode Reimbursement
Intercept	43,548 *	52,346 *	104,166 *
Rural	-2,236 *	-3,157 *	-6,701 *
(urban)			
Non-Teaching	-9,114 *	-8,773 *	-18,757 *
Minor Teaching	-7,606 *	-7,750 *	-16,609 *
(major teaching)			
< 100 beds	850 *	230	2,115 *
100-199 beds	1,450 *	1,468 *	4,065 *
200-299 beds	34	-383 *	129
300-399 beds	551 *	334 *	1,340 *
400-499 beds	-409 *	-565 *	-559 *
500-599 beds	-892 *	-1,019 *	-1,732 *
600-699 beds	-1,709 *	-2,133 *	-4,203 *
700-799 beds	553 *	472 *	1,503 *
(> 799 beds)			
age < 65	-3,193 *	-3,035 *	-7,939 *
age 65-69	-2,219 *	-2,459 *	-7,338 *
age 70-74	-1,429 *	-1,838 *	-5,688 *
age 75-79	-893 *	-1,235 *	-4,018 *
age 80-84	-499 *	-752 *	-2,373 *
(age > 84)			
male	-481 *	-264 *	-1,615 *
(female)			
unknown race	-806 *	-2,026 *	-4,362 *
white	-651 *	-1,807 *	-3,798 *
black	490 *	-771 *	-1,238 *
(other race)			
DRG 106	-2,913 *	-2,921 *	-7,660 *
DRG 107	-7,019 *	-7,889 *	-13,790 *
(DRG 108)			
1990 Discharge	-2,979 *	-2,105 *	-5,742 *
1991 Discharge	-2,281 *	-1,073 *	-3,802 *
1992 Discharge	-393 *	419 *	7
(1993 Discharge)			
Discharged Alive	-6,428 *	-7,369 *	-10,594 *
(died in-hospital)			
R-squared	0.18	0.19	0.13
N. of observations	483,501	368,563	368,563

NOTE:

1 Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19

2 Calendar year data. 1993 values are based on discharges through September 30th

3 Hospital inpatient reimbursement includes Medicare Part A expenditures for the bypass stay

4 Hospital and physician/supplier inpatient reimbursement includes Medicare Part A and Part B expenditures for the bypass stay

5 Bypass episode reimbursed includes all hospital, SNF, physician/supplier, home health and outpatient department expenditures from 30 days pre-bypass admission to 90 days post-discharge

6 Hospital and physician/supplier and total bypass episode regressions include only patients with inpatient physician/supplier expenditures >$1,000

SOURCE: 1990-93 MedPAR and NCH files

costs for DRG 106 and DRG 107 are not much affected when considering the entire bypass episode (rather than just the bypass stay). Since patients in DRG 107 undergo catheterization before the bypass admission, the additional costs during the 30 days prior to bypass for 107 patients was expected to reduce the payment differential.

While the hospital bedsize coefficients are generally significant (compared to the largest hospitals) no relationship is obvious, and several of the coefficients are relatively small. This indicates that much of the variation in payment by hospital size (seen in Table 2-13) is caused by the correlation between size and other factors such as teaching status.

All the patient characteristic variables are significant. This is somewhat surprising for PPS hospital inpatient reimbursement, given that bypass DRG payments do not vary with patient demographic factors or patient discharge status. However, payments are increased for outliers, and differences in the proportion of patients who meet outlier thresholds by characteristic could explain the significance of these variables. This may also explain the lower costs of patients discharged alive, if patients who die in the hospital tend to exceed outlier thresholds. The coefficients on the patient characteristic variables are larger in the total bypass episode regression, reflecting varying utilization of care associated with, say, age.

Controlling for other factors, a strong trend is found in inpatient expenditures across the years. Compared with 1993, average 1990, 1991, and 1992 hospital inpatient outlays were roughly $3,000 less, $2,300 less, and $393 less. When inpatient physician services are included, the trend is not nearly as large in absolute terms. Finally, once other variables are controlled for patients discharged in 1993 were $5,742 more expensive on a total episode basis compared with 1990, and $3,802 more compared with 1991. Interestingly, no net cost difference is found between 1992 and 1993.

3.0 SELECTION OF DEMONSTRATION PARTICIPANTS

Because the negotiated bundled hospital and physician price for CABG surgery is such a departure from existing reimbursement methods, involving major changes in internal coordination and payment controls within the sites, it is key to explain the basic decision to participate. At bottom is the question of selection bias, not at the patient level as it is ordinarily understood, but at the site level. While not necessarily a problem, bias could severely limit the generalizability of the findings to future applicants. For instance, demonstration applicants may be more financially vulnerable and permit HCFA to negotiate larger discounts than future, more financially secure, applicants.

The basic decision to participate (or apply) can be decomposed into a set of static, current, considerations as well as a set of dynamic, future, expectations. Current considerations are summarized in the question each applicant must answer, "What is in it for us right away?" If an applicant felt that it could negotiate an all-inclusive price that exceeded current total reimbursements, it might apply. A rate set below current payments, on the other hand, does not mean below current costs. Where CABG surgery is already profitable, other factors may be given more weight in the decision to participate; thereby encouraging participation even at a rate lower than currently paid.

Most of the dynamic reasons for participating can be summed up in the phrase, "it will be good for business," or, in a word, volume. If the hospital has high fixed costs and underutilized capacity, then marginal costs may be below any price it might negotiate with HCFA.

Theory suggests several interesting hypotheses. For example, hospitals with unused capacity and higher fixed costs should be more likely to apply. Spillover effects on other patient demand will be important. Hospitals with several local CABG competitors should be more likely to apply, ceteris paribus. Because of higher bad debts, hospitals in areas with less supplemental coverage should be more likely to apply. And, finally, hospitals with the majority of their physicians on salary should be more likely to apply.

3.1 Application Process

Over 700 hospitals performed CABGs on Medicare patients in 1986; yet only 206 applied. Certainly, the majority who didn't apply realized that they lacked the requisite volume, but some potential applicants may not even have submitted letters of intent. Of the

206 submitting letters, only 42 were invited by HCFA to apply of which 27 actually submitted full applications. Lewin/VHI and HER staff reviewed all 27 applications.

The wide range of bids among the 27 hospitals was surprising. Although most were competitive, and some offered substantial discounts on current payments, several hospitals appeared to be bidding premium, rather than discounted, prices. These cannot be considered serious bids, in spite of the fact that they were well-qualified institutions that worked hard in preparing their bids. Of the 42 hospitals invited to participate, only a small handful (less than 15) were prepared to offer meaningful discounts for the privilege of being called Medicare Heart Bypass Centers. Without the threat of exclusive contracting, HCFA's ability to negotiate substantial reductions for a significant number of high cost, prestigious, institutions is severely limited.

3.2 Evaluation of Bids and Negotiations

HCFA established an outside panel of experts to review the quality of each institution and evaluate the competitiveness of each bid. This process narrowed down the candidates from 27 to ten.

At this point, the evaluation contractor was asked to conduct an in-depth review of each proposal and rank the ten finalists along a number of dimensions.

3.2.1 Ranking the Ten Finalists

Applicants were ranked according to 11 criteria. Four related to price: (1) relative prices; (2) discount rates; (3) financial risk; and (4) volume discounts. Relative prices involved comparisons with other local bypass hospitals. Financial risk involved a subjective evaluation of the risk accepted by the bidder for high cost cases. Applicants were also ranked on their breadth of service coverage, including: (5) coverage of unrelated procedures; and (6) coverage of readmissions. They were also ranked on their quality of care measured in two ways: (7) severity-adjusted mortality rates; and (8) appropriateness of care. The latter depended primarily on average lengths of stay. The final three criteria were: (9) financial incentives offered patients and referring physicians; (10) the quality of the bypass information systems; and (11) total Medicare and non-Medicare bypass volume.

Applicants were given a score of 0-100 on each criterion using the full range of the scale. An aggregate score was derived using subjective weights reflecting the importance of each criterion. In the basic ranking, the four price elements together were given a weight of 50

percent. The two quality measures together were weighted 25 percent; the two service characteristics, 10 percent total; beneficiary incentives, information systems, and total volume were weighted 5 percent each. Based on these weighted scores, the ten finalists were then ranked from 1 to 10. Because the weighting process was necessarily subjective, sensitivity analysis was used to test the robustness of the rankings by varying the weights. Changing the weights had little effect on the ranking of the top 4-5 hospitals.

3.2.2 Evaluating Price Discounts

The next stage involved extensive negotiations with the top applicants, including face-to-face meetings at HCFA/ODE in Baltimore, Maryland. The most challenging aspect of these negotiations was verifying the price discount being offered by the applicants. This required linking Part B physician bills with the corresponding Part A hospital bills. While the addition of pass-throughs complicates the issue, the Part A calculations are still relatively straightforward. Armen Thoumaian, the Project Officer at HCFA/ODE, with the assistance of Edward Berends, used MDRS data to derive estimates of the average Part B expenditures paid to physicians treating bypass patients in the applicant hospitals. This is a challenging task given the hundreds of hospitals performing CABG surgery in the U.S. and the voluminous bills that must be aggregated and linked by patient ID to Part A bills.

Many problems arose in deriving the benchmark cost estimates used to evaluate each applicant's bid. First, there was the problem of erroneous or missing data. Some Part A bills, for example, had no Part B surgeon's bill, resulting in very low overall costs. Second, there was the question of the scope of included physician bills, given that most applicants did not cover all physicians in their global bid. Outlier trims were used as a rough approach to incomplete data.

In the end, this cost-finding process added considerably to the time and effort in negotiating final bids. The process was extended further in order to complete the OMB waiver cost estimates designed to show the expected savings from the demonstration. If HCFA decided to implement this approach nationwide, it would first have to undertake a major data processing effort using the National Claims History Files.

The size of the average proposed discount across the two DRGs covered under the demonstration varied considerable across the 10 finalists. Four hospitals submitted bids that actually implied premiums, rather than discounts, as their proposed rates were higher than the expenditures projected by HCFA. Two of these four hospitals offered discounts on the Part A hospital expenditures but proposed Part B physician payments that were more than 40 percent

greater than the HCFA Part B estimates. The other two hospitals submitted proposals calling for premium payments to the hospital for participating. A fifth hospital submitted a proposal with rates identical to HCFA's projected expenditures, implying no premium or discount. The remaining five hospitals proposed rates that were discounted relative to projected expenditures.

3.2.3 Negotiations

To focus the negotiations on the ambiguous points in the applicants' proposals, the evaluation staff then produced a negotiation protocol to be used by HCFA/ODE staff in face-to-face meetings with the applicant. (Evaluation staff were not included in these negotiations.) The protocol was based on an in-depth review of each proposal. Questions were developed relating to price, beneficiary incentives, quality assurance, and information systems. HCFA/ODE staff then arranged and completed the negotiation phase.

After negotiations were completed and the original four hospitals were selected, HCFA/ODE sent out a letter asking the six excluded applicants if they would like to reconsider their initial bid. In response, three of the six resubmitted new bids, and the government successfully negotiated rates with these hospitals. As a result, St. Vincent's Hospital in Portland, Oregon, St. Luke's Hospital in Houston and Methodist Hospital in Indianapolis were added to the demonstration in mid-1993, two years after the start of the original demonstration.

3.2.4 Updating the Negotiated Prices

The negotiated prices went into effect for the four original demonstration hospitals in May and June 1991. The negotiated prices have been updated annually for three of the demonstration sites, with the new prices effective January first of each year. The fourth site, Ohio State University Hospital, agreed during the negotiation process to forego updates. The reader is referred to Volume II, Appendix 3, for HCFA's detailed update methodology. Below, we give a brief summary of the method.

The annual Part A update amount is the difference between the DRG operating amounts for the two years under the prospective payment system. The DRG operating amount consists of the DRG base payment, plus any disproportionate share, and indirect medical education adjustments. The DRG base payment is constructed using the DRG relative weight, the hospital wage index, and national and regional adjusted standardized amounts for labor and nonlabor inputs. Thus, the DRG base payment can vary over time as HCFA updates

each of these components. For example, the national relative weight for DRG 107 was reduced from 4.7899 in 1991 to 4.2348 in 1993 (St. Anthony Publications, 1991, 1993), leading to a reduction the DRG base payment to demonstration hospitals, ceteris paribus. The disproportionate share factor is based upon the number of inpatient admission days for disabled Social Security recipients receiving Supplemental Security Income and for Medicaid patients as a proportion of total inpatient days. The figure used for the indirect medical education factor is based on interns and residents information used by the Fiscal Intermediary for each hospital.

The annual Part B update is derived by estimating the change in payment for a typical package of physician/supplier services provided during the bypass hospitalization. A typical bundle of services was constructed using CPT-4 codes of the most essential physician services for DRG 106 and 107 combined with estimates of other consulting services typically occurring during the bypass surgical episode. The bundle was based on over 100 bypasses performed at St. Joseph's Hospital in Atlanta. See Appendix 3 for more detail. The change in allowable payments for this bundle was then estimated to construct the update.

Calculation of payment for this bundle was complicated by the introduction of the Medicare Fee Schedule in January, 1992. The annual updates have been adjusted to reflect the transition of payments used to phase in the fee schedule.

3.2.5 Success of Negotiation Process

One of the most important criteria in determining the success of the demonstration is the size of the price discount achieved through selective contracting. The government's negotiating leverage is limited by the Congressional proscription against exclusive contracting. Medicare beneficiaries can still use any hospital they choose for bypass surgery and the government will pay the appropriate DRG rate for Part A and the allowable fees for all Part B physician services. What the government is offering, then, is an imprimatur: the Medicare Heart Bypass Center. This presumably confers status and quality and can be used by the applicant in its marketing efforts. Each hospital-physician team in the country had to evaluate the worth of this imprimatur relative to their own costs, the likely competitive responses of other local hospitals, and any advantages of being in a demonstration that might become national policy.

In spite of its limited bargaining position, HCFA/ODE staff were able to negotiate sizable discounts of 10 percent or more in the four original participating hospitals (see Table 3-1). Some of the discounts were modest only because Medicare payments were already quite

TABLE 3-1

NEGOTIATED DISCOUNTS AT THE DEMONSTRATION HOSPITALS

	1991		1992		1993	
	DRG 106	DRG 107	DRG 106	DRG 107	DRG 106	DRG 107
Original Demonstration Sites						
St. Joseph's Hospital - Atlanta						
Payment in Lieu of Demonstration	$29,305	$26,249	$30,550	$27,995	$30,928	$24,731
Negotiated Payment	26,393	23,303	26,434	23,923	27,532	21,693
Discount (Dollars)	2,912	2,946	4,116	4,072	3,396	3,038
Discount Rate	9.9 %	11.2 %	13.5 %	14.5 %	11.0 %	12.3 %
University Hospital - Boston						
Payment in Lieu of Demonstration	46,330	42,970	46,706	44,310	46,795	38,751
Negotiated Payment	35,181	33,671	35,185	34,569	36,566	30,566
Discount (Dollars)	11,149	9,299	11,521	9,741	10,229	8,185
Discount Rate	24.1 %	21.6 %	24.7 %	22.0 %	21.9 %	21.1 %
Ohio State University Hospital						
Payment in Lieu of Demonstration	37,341	33,296	37,446	34,228	39,864	31,382
Negotiated Payment	26,952	21,092	26,952	21,092	26,952	21,092
Discount (Dollars)	10,389	12,204	10,494	13,136	12,912	10,290
Discount Rate	27.8 %	36.7 %	28.0 %	38.4 %	32.4 %	32.8 %
St. Joseph Mercy - Ann Arbor						
Payment in Lieu of Demonstration	35,762	31,782	35,359	32,143	37,783	29,788
Negotiated Payment	32,282	25,578	32,629	26,537	35,470	24,683
Discount (Dollars)	3,480	6,204	2,730	5,606	2,313	5,105
Discount Rate	9.7 %	19.5 %	7.7 %	17.4 %	6.1 %	17.1 %
Expansion Demonstration Sites						
St. Vincent's Hospital - Portland, OR						
Payment in Lieu of Demonstration	-	-	-	-	34,613	27,655
Negotiated Payment	-	-	-	-	30,386	26,100
Discount (Dollars)	-	-	-	-	4,227	1,555
Discount Rate	-	-	-	-	12.2 %	5.6 %
Methodist Hospital - Indianapolis						
Payment in Lieu of Demonstration	-	-	-	-	36,140	28,490
Negotiated Payment	-	-	-	-	33,982	25,934
Discount (Dollars)	-	-	-	-	2,158	2,556
Discount Rate	-	-	-	-	6.0 %	9.0 %
St. Luke's Hospital - Houston						
Payment in Lieu of Demonstration	-	-	-	-	36,491	28,993
Negotiated Payment	-	-	-	-	34,078	27,040
Discount (Dollars)	-	-	-	-	2,413	1,953
Discount Rate	-	-	-	-	6.6 %	6.7 %

NOTE: The four original demonstration hospitals began receiving bundled payment in May-June 1991.
The three expansion hospitals began receiving bundled payment in June 1993.

SOURCE: Health Care Financing Administration, Office of Research and Demonstration.

low. For example, the discount rates for St. Joseph's in Atlanta were much lower than for University Hospital in Boston. However, the regular payments to St. Joseph's are $14 - $17 thousand lower than to University Hospital, making it impossible for them to offer as large a discount. Disappointing were the bids of some of the more costly teaching hospitals. These institutions were not willing to offer significant discounts, presumably feeling secure in their competitive position and not fearing substantial loss of volume. How these hospitals would respond to a national program with voluntary participation is unclear. Even less clear would be their response if Congress permitted HCFA to negotiate exclusive contracts in various cities. Given the very high marginal profits hospitals appear to enjoy from bypass surgery (see Chapter 6), many would likely be willing to offer substantial discounts rather than forego Medicare bypass patients altogether.

3.3 Demonstration Hospital Reasons for Participating

As part of an initial 2-day site visit, the evaluation team asked several questions about the hospital's decision to participate. What follows is an analytic synopsis of responses by hospital administrators and physicians.

3.3.1 Competitive Pressures

A major reason to participate in the demonstration was competitive pressures, both currently in local markets as well as expected competition in the future. All four original participating institutions are in highly competitive markets: Atlanta, Boston, Columbus, and Ann Arbor. All face at least one serious local competitor in open heart surgery, and most face several competitors. Interestingly, possibly because of who they were, only two of the four were concerned about their national reputation. All had concrete reasons for wanting to protect or expand their current market.

Competition encouraged them to apply in three ways. First, they were concerned about HCFA's future contracting intentions. If the Agency was going to "go national" with the program, they wanted to be on the included list of providers, particularly if HCFA was allowed to engage in selective contracting. Second, they were very concerned about the interest other payers had in bundled CABG payments. Several managed care and regular private insurers had already contacted them about a packaged CABG product with a single, guaranteed rate. A failure to be on HCFA's preferred provider list could also cut into their private market. And third, they were generally concerned about the possibility of not applying and having a local competitor be named a Medicare Heart Bypass Center. Uncertainty about who was bidding,

reinforced by local rumors, "forced" some hospitals to bid even if unsure of the cost consequences.

How important was local or national market position in deciding whether to bid? Although none of the four selected demonstration hospitals were nationally recognized open heart centers, many prestigious centers did apply but were not selected initially. Within their local markets, it is also true that three of the four demonstration hospitals were either the largest bypass provider or, in the case of Ohio State University, a financially secure institution that could afford the risk of not participating. Thus, while competitive concerns were prominent in the decision to apply, they were not the only ones.

All participants recognized the spillover effects on other business and wanted to protect their open heart market share and reputation. Bypass surgery, more than most procedures, relies on a far-flung referral network to generate enough cases to support the surgical team and intensive care services. Marketing the hospital as a Medicare Heart Bypass Center was felt to strengthen its referral network as well as protect it against encroachments from established or new competitors. How effective HCFA's imprimatur is in gaining market share is open to question, however. Some surgeons felt that because they were already doing heart transplants, being designated a Medicare Bypass Center would add little to the hospital's prestige.

3.3.2 Bypasses and Profits

From the hospital's perspective, bypass surgery is generally considered a profitable procedure. All four participating hospitals were seeking to expand volume, even if average costs remained constant, because it more than covered variable costs.

Interestingly, the hospital's desire to increase volume in order to drive down average costs was not an important reason for applying. It is true that administrators in St. Joseph's Mercy in Ann Arbor and at Ohio State University Hospital were concerned about their high costs, but in general they did not expect the large volume growth necessary to produce significant scale economies. Other participants were low-cost hospitals already.

What was emphasized in these hospitals was the need to put physicians under the same capitated payment incentives that the hospital was under. In order to compete on price for private business and to keep costs below DRG rates, some administrators felt that physicians had to join the hospital team to better manage the whole course of care. Specifically, managers were concerned about lengths of stay in the ICU and routine accommodations and the expensive testing and drugs patients received.

A striking impression one had in visiting the four sites was the economic advantages of concentrating on a few services. St. Joseph's Hospital in Atlanta is the pre-eminent example of

the economies to be realized by narrowing the scope of services. It is one of the lowest cost bypass hospitals in the nation. Of the 42 hospitals invited to submit final applications, it ranked fourth (behind The Cleveland Clinic, the Texas Heart Institute, and the University of Alabama) in total bypasses in 1987. St. Joseph's was by far the smallest hospital (346 beds) to be considered in the final ten. Nevertheless, it performed 5.1 bypass surgeries per bed compared to only 2.2 per bed at The Cleveland Clinic or St. Luke's (THI). According to its administrators, roughly 70% of its casemix is cardiac related. It has 50 cardiologists on staff, one for every 6 beds. Its Medicare casemix in 1991 was roughly 2.1, even though it is a nonteaching institution. Its surgeons perform 30-50 heart transplants annually. It has a burgeoning angioplasty service performing several thousand PTCAs a year. Despite its size and limited national recognition at the start of the demonstration, this hospital knows how to treat heart cases.

Contrast this focus with other major university settings who applied to the demonstration. None performed more than 0.5 bypasses per bed; one-tenth the concentration rate of St. Joseph's. Certainly, these institutions knew how to perform successful open heart surgery as well, but their diversified casemix undoubtedly strains their clinical and management resources which adds to costs.

3.3.3 The Physician's Role in the Participation Decision

Two physician specialties are key in the participation decision: thoracic surgeons and cardiologists. Without doubt, cooperation of the thoracic surgeons is critical to participation. Hospitals appear to have little control over these specialists, who have numerous opportunities to practice elsewhere. Among the demonstration hospitals, the surgeons were interested in expanding their practices, although to varying degrees. But because they are already well paid, the notion of a single bundled payment presents unnecessary financial risk to some.

Surgeon support for participation can go either way in spite of the extra risk. In one site, for example, the thoracic surgeons felt that the hospital was not giving them the attention and support (i.e., operating room time) they deserved. By becoming a Bypass Center, they hoped that open heart surgery would receive more attention. This argument was less explicit in the other sites, but the surgeons' interest in hospital marketing of bypass surgery was closely related to the desire for "institutional support."

Cardiologists generally viewed bypass surgery as complementary to their activities. Only recently with the introduction of cardiac angioplasty has the cardiologist invaded the surgeon's territory as a direct competitor. Nevertheless, cardiologists still appeared supportive of the Bypass Center concept and felt it would strengthen their referral network as well.

3.3.4 Teaching Hospital Participation

A disproportionate number of bypass hospitals train interns and residents, and 37 of the 42 institutions invited to submit full proposals were teaching hospitals. (St. Joseph's in Atlanta was a notable exception.) This does not mean that they are more likely to apply, however. Of the four demonstration hospitals, Ohio State and Boston University Hospitals are directly linked to a medical school. There was little indication, though, that surgeons were coerced into participating. Many faculty surgeons were interested in expanding their practices and saw the advantages of being involved in a Medicare Heart Bypass Center as a marketing tool.

What was most striking about major teaching hospitals was not their greater likelihood of participating but rather the opposite. Hospitals affiliated with medical schools were less likely to offer substantial discounts and, hence, be selected for two reasons. First, and most important, they are the flagship institutions in their communities. They enjoy high occupancy rates and extra Medicare reimbursements for teaching. Most presume that they will be part of a selective contracting system if Medicare goes national with bypass packaging. And second, they generally have severe constraints on operating room access and ICU beds. Very few are willing to focus more on bypass surgery, particularly as it becomes more routinized. Consequently, even if thoracic surgeons and cardiologists desired expansion, the hospital often cannot accommodate them to any great extent; this, in spite of the fact that bypass surgery is perceived as a profitable activity that cross-subsidizes other teaching and research. This may also explain why the bids of many well-known teaching hospitals were uncompetitive. Ohio State University is an exception in this regard and may be explained by a desire to rebuild a surgical program that languished in the early 1980s. It is also facing exceptionally vigorous local and regional competition.

4.0 COMPARATIVE ANALYSES OF DEMONSTRATION VERSUS COMPETITOR HOSPITAL VOLUMES

4.1 Evaluation Questions

This chapter presents findings on Medicare bypass volumes and market shares for the seven hospitals funded under Medicare's Heart Bypass Center Demonstration. The issues addressed in the chapter can be summarized by the following questions:

- Did participation in the demonstration lead to changes in hospital Medicare bypass volumes?
- Did participation in the demonstration lead to changes in hospital Medicare bypass market shares?
- What was the distribution of Medicare bypass cases by DRG in the demonstration hospitals? Did this distribution change after the start of the demonstration?
- Did demonstration hospitals treat a demographic mix of patients that differs from their competitors? Did the demographic mix of patients change after the start of the demonstration?
- Did average length of stay for Medicare bypass patients change after the start of the demonstration?

All of the demonstration sites hoped that the prestige of being named a "Medicare Participating Heart Bypass Center" would lead to growth in the number of bypasses performed at the hospital. Thus, we are interested in knowing whether designation as a demonstration site did in fact lead to volume gains and whether such gains were due to (a) the general growth in CABG surgery, or (b) a shift in existing demand away from local (and outside) competitors. If all of the demonstration sites' volume increases were due to the growth in CABG surgery generally, then there are no competitive advantages to being a Center. Thus, in Section 4.4 we present the volumes and market shares for bypass surgery of both demonstration and competitor hospitals.

Bypass patients are classified primarily into two DRGs: DRG 106 for bypass with catheterization; and DRG 107 for patients who have undergone angiography prior to the bypass admission. Thus, a high proportion of patients in DRG 107 is indicative of a referral

center for bypass surgery. In Section 4.5 we examine changes in the proportion of patients by DRG to determine whether shifts in bypass volumes have been accompanied by changes in the proportion of patients who were referred to the hospital after their angiography was completed.

Hospitals can increase profits, even with lower per case payments, if they can reduce resource utilization sufficiently to offset the lower reimbursement. One method by which the hospital could achieve this is by changing its casemix, admitting patients who are less severely ill who require fewer resources. Our claims data do not provide detailed information on patients' medical conditions, such as degree of stenosis, with which to measure severity. However, they do provide us with data on the patient's age, gender, and race, that can be compared across time to see if there have been shifts in the type of patients the hospital treats since the implementation of the demonstration. These issues are discussed in Section 4.6.

Another method of increasing productivity is through shorter lengths of stay. National figures presented in Chapter 3 indicate that the average length of stay has fallen by several days since 1990. In Section 4.7 we compare lengths of stay for the demonstration hospitals and their competitors to determine whether the demonstration sites have been successful in shortening stays more than other hospitals.

4.2 Methods and Data

4.2.1 Pre/Post Study/Control Quasi-Experimental Design

This study uses a quasi-experimental design with seven demonstration hospitals matched to seven control groups. A simpler experimental design would have tested for changes using pre- and post-demonstration data only from the demonstration sites themselves. Some of the research questions can be answered in an absolute sense using only data from the demonstration sites (e.g., did Medicare bypass volumes change in the demonstration hospitals?). However, absolute changes by themselves are not particularly meaningful, given the secular trends in bypass surgery. For example, we know (from Chapter 2) that the number of bypasses performed nationally grew by 14 percent between 1990 and 1993. At a minimum, the trend for the demonstration sites should be compared with the national trend.

Many other research questions demand additional information from non-demonstration sites, calling for a quasi-experimental design. For example, the question "Did market shares change for the demonstration hospitals?" cannot be addressed without information on competitor volumes. Thus, the competitor hospitals naturally form the "control" group for addressing this question. Use of these controls adjusts for growth or

shrinkage in local bypass markets that may differ from the national trend towards higher volumes. The comparison groups control for idiosyncratic local factors that may account for changes in Medicare bypass volumes independent of participation in the demonstration. They also serve as controls for examining bypass casemix and length of stay changes during the demonstration.

4.2.2 Original vs. New Participants

The Medicare bypass demonstration now involves seven hospitals around the country. Four original sites started receiving bundled payments in June, 1991. Three "expansion" sites joined the demonstration in June, 1993. Although we generally present similar data for both the original and expansion sites, care must be taken in interpreting the results. For the original sites, we have over two years worth of post-demonstration data, which allows us to examine the effects of the demonstration, at least in the short run. For the expansion sites, we are presenting extensive background material and cannot make any inferences regarding the effects of the demonstration. We have fourteen quarters of pre-demonstration data for these sites, but only one quarter of post-demonstration data.

4.2.3 Definitions of Demonstration Hospital Markets

Since bypass surgery is often non-urgent, yet a costly, technologically complex procedure, patients may be willing to travel much further for treatment than would be the case for many other conditions. In addition, patient triaging is sensitive to the local physician networks. Cardiologists tend to refer patients to surgeons and facilities that they know and that have treated prior patients successfully. Thus, markets for bypass surgery do not conform to geographic designations such as cities or counties.

Construction of markets for the seven demonstration hospitals was a two-step process. First, all hospitals located within the same metropolitan statistical areas (MSAs) as the demonstration sites were first identified. Second, demonstration sites were asked who they viewed as competitors for patients, and were allowed to list hospitals outside of their immediate metropolitan areas. While some hospitals added no competitors outside their MSAs, several, particularly those in smaller metropolitan areas, listed additional hospitals whom they considered competitors. While this method of constructing markets introduces an element of discretion, it results in a more meaningful set of competitors than a simple geographic definition.

Table 4-1 lists the hospitals in each of the seven demonstration markets along with their location, bedsize, teaching status, and ownership. Within each market, the demonstration hospital is listed first and bolded. St. Joseph's Hospital in Atlanta, at 346 beds, is smaller than all five of its competitors. It is the only non-teaching hospital in the market, and the only non-teaching demonstration site. University Hospital in Boston is in competition with eight other major teaching hospitals in the Boston MSA, and also considers Catholic Medical Center in Manchester, New Hampshire, roughly 60 miles from Boston, a competitor, as shown in Exhibit 4-1. With 341 beds, University Hospital is the smallest demonstration hospital. Ohio State University Hospital considers itself competitive for bypass cases with nine hospitals located across Ohio, shown in Exhibit 4-2. Four competitors are located in Columbus (with OSU Hospital), two are in Cleveland, and one each are in Cincinnati, Dayton, and Toledo. Like seven of its competitors, Ohio State University Hospital is a major teaching facility. St. Joseph Mercy Hospital in Ann Arbor considers eleven hospitals located in central and eastern Michigan as competitors, shown in Exhibit 4-3. At 618 beds, St. Joseph Mercy is larger than all but three of its competitors, and is a major teaching facility.

Among the three expansion sites, St. Vincent's Hospital is the largest of the five hospitals doing CABG surgery in Portland, Oregon and is a minor teaching hospital. Methodist Hospital in Indianapolis, with 1,051 beds is the largest of the seven demonstration hospitals. It faces competition from four other hospitals in the MSA. St. Luke's is one of fifteen hospitals performing bypass surgery in the Houston MSA. A major teaching facility with 696 beds, it is the only demonstration hospital facing competition from for-profit hospitals.

4.2.4 Data Sources

Data for this analysis come from the Medicare MedPAR Part A claims files. After the files containing all Medicare bypasses in the nation were cleaned once edited as described in Chapter 2, claims for patients treated in the demonstration hospitals and their competitors were identified. Volumes and market shares were then constructed for each hospital. Other variables, such as demographic characteristics of patients, mortality, and length of stay are separate fields on the MedPAR file. Examination of the data revealed extremely short average stays in the Portland market, resulting from HMO patients who were transferred to another acute care facility shortly after the bypass surgery. To prevent these patients from biasing the stay estimates downward, HMO enrollees were excluded from all length of stay analyses.

TABLE 4-1

MEDICARE PARTICIPATING HEART BYPASS CENTER DEMONSTRATION HOSPITALS AND THEIR COMPETITORS

Original Demonstration Sites	Metropolitan Area	Hospital Beds	Percentage of Beds in Market	Teaching Status	Ownership
Atlanta					
Saint Joseph's	**Atlanta**	**346**	**11%**	**Non**	**Not-for-profit**
Emory University	Atlanta	532	17	Major	Not-for-profit
Crawford Long	Atlanta	461	15	Major	Not-for-profit
Grady Memorial	Atlanta	927	30	Major	Public
Piedmont	Atlanta	474	15	Minor	Not-for-profit
Georgia Baptist	Atlanta	374	12	Major	Not-for-profit
Boston					
University Hospital	**Boston**	**341**	**7**	**Major**	**Not-for-profit**
Mount Auburn	Boston	290	6	Major	Not-for-profit
St. Elizabeth's	Boston	350	8	Major	Not-for-profit
Massachusetts General	Boston	1,014	22	Major	Not-for-profit
Beth Israel	Boston	504	11	Major	Not-for-profit
Brigham & Women's	Boston	726	16	Major	Not-for-profit
New England Medical Center	Boston	461	10	Major	Not-for-profit
New England Deaconess	Boston	365	8	Major	Not-for-profit
Lahey Clinic	Boston	272	6	Major	Not-for-profit
Catholic Memorial	Manchester	292	6	Non	Not-for-profit
Columbus					
Ohio State	**Columbus**	**657**	**10**	**Major**	**Public**
University of Cincinnati	Cincinnati	707	11	Major	Public
Riverside Methodist	Columbus	856	13	Major	Not-for-profit
Grant Medical Center	Columbus	423	6	Major	Not-for-profit
Mount Carmel Health	Columbus	764	12	Minor	Not-for-profit
Medical College of Ohio	Toledo	291	4	Major	Public
Miami Valley	Dayton	757	12	Major	Not-for-profit
University Hospital	Cleveland	749	11	Major	Not-for-profit
Doctors Hospital	Columbus	417	6	Non	Not-for-profit
Cleveland Clinic	Cleveland	897	14	Major	Not-for-profit
Ann Arbor					
St. Joseph Mercy - Ann Arbor	**Ann Arbor**	**618**	**9**	**Major**	**Not-for-profit**
Sinai Hospital	Detroit	498	8	Major	Not-for-profit
St. Joseph Mercy	Detroit	450	7	Minor	Not-for-profit
University of Michigan	Ann Arbor	875	13	Major	Not-for-profit
Henry Ford	Detroit	778	12	Major	Not-for-profit
St. Joseph	Flint	423	6	Minor	Not-for-profit
Harper	Detroit	580	9	Major	Not-for-profit
Ingham Medical Center	Lansing	258	4	Major	Public
William Beaumont	Detroit	874	13	Major	Not-for-profit
Mclaren Regional Medical Center	Flint	436	7	Minor	Not-for-profit
Detroit Osteopathic	Detroit	150	2	Non	Not-for-profit
St. John's	Detroit	575	9	Major	Not-for-profit

TABLE 4-1

MEDICARE PARTICIPATING HEART BYPASS CENTER DEMONSTRATION HOSPITALS AND THEIR COMPETITORS

Expansion Demonstration Sites	Metropolitan Area	Hospital Beds	Percentage of Beds in Market	Teaching Status	Ownership
Portland					
St. Vincent	**Portland**	**451**	**24%**	**Minor**	**Not-for-profit**
Emanuel Hospital	Portland	349	18	Minor	Not-for-profit
University Hospital	Portland	348	18	Major	Public
Good Samaritan	Portland	319	17	Minor	Not-for-profit
Providence Medical Center	Portland	439	23	Minor	Not-for-profit
Indianapolis					
Methodist	**Indianapolis**	**1,061**	**28**	**Major**	**Not-for-profit**
St. Vincent	Indianapolis	857	23	Minor	Not-for-profit
Indiana University	Indianapolis	591	16	Major	Public
St. Francis	Indianapolis	434	12	Minor	Not-for-profit
Community Hospital	Indianapolis	822	22	Non	Not-for-profit
Houston					
St. Luke's	**Houston**	**696**	**9**	**Major**	**Not-for-profit**
St. Joseph	Houston	606	8	Minor	Not-for-profit
Hermann	Houston	575	7	Major	Not-for-profit
Bayshore	Houston	347	4	Non	For Profit
Memorial	Houston	830	10	Minor	Not-for-profit
Medical Center Hospital	Houston	169	2	Non	Public
Methodist	Houston	1,197	15	Major	For Profit
Memorial City	Houston	129	2	Non	For Profit
Humana	Houston	467	6	Non	For Profit
HCA Spring Branch	Houston	298	4	Non	For Profit
Houston Northwest	Houston	390	5	Non	For Profit
Harris County Hospital District	Houston	984	12	Major	Public
Sam Houston Memorial	Houston	181	2	Non	For Profit
HCA West Houston Medical Ctr.	Houston	131	2	Non	For Profit
HCA Medical Center Hospital	Houston	144	2	Non	For Profit
University of Texas	Galveston	785	10	Major	Public

NOTES: 1) Within each market, the demonstration hospital is listed first and bolded.

2) The original demonstration sites began the demonstration June 1991. The expansion demonstration sites began the demonstration June 1993.

SOURCE: American Hospital Association.

Exhibit 4-1
Massachusetts and New Hampshire

Boston

University Hospital
St. Elizabeth's Hospital
Massachusetts General Hospital
Beth Israel Hospital
Brigham & Women's Hospital
New England Medical Center
New England Deaconess Hospital

Cambridge

Mount Auburn Hospital

Burlington

Lahey Clinic

Manchester

Catholic Medical Center

Exhibit 4-2
Ohio

Columbus

Ohio State University Hospital
Riverside Methodist Hospital
Grant Medical Center
Mount Carmel Hospital
Doctors Hospital

Cleveland

Cleveland Clinic
University Hospitals of Cleveland

Cincinnati

University of Cincinnati Hospital

Dayton

Miami Valley Hospital

Toledo

Medical College of Ohio

Exhibit 4-3
Michigan

Miles
0 20 40 60 80

Ann Arbor

St. Joseph Mercy Hospital-Ann Arbor
University of Michigan Hospital

Detroit
Sinai Hospital
Henry Ford Hospital
Harper Hospital
St. John Hospital

Flint
St. Joseph Hospital
McLaren Regional Medical Center

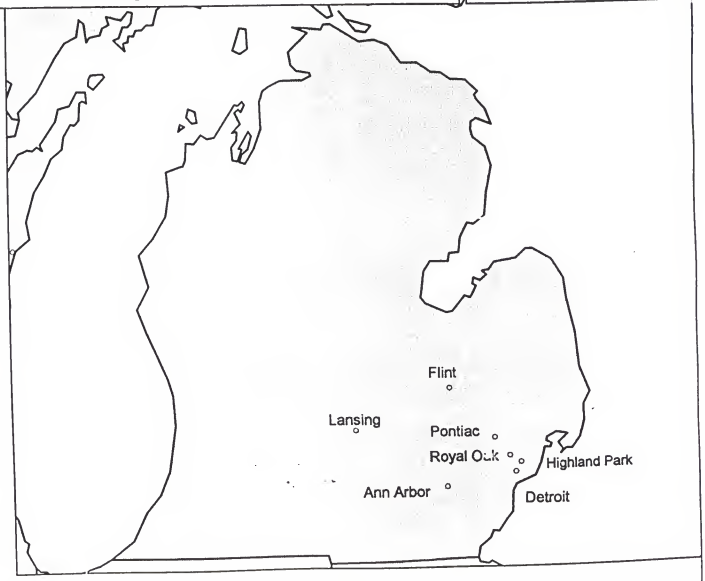
Highland Park
Detroit Osteopathic Hospital

Lansing

Ingham Medical Center

Pontiac
St. Joseph Mercy Hospital-Pontiac

Royal Oak
William Beaumont Hospital



4.3 Medicare Bypass Volume and Market Shares by Site by Year

Table 4-2 shows the number of CABGs performed in each of the demonstration markets for 1990, 1991, 1992, and 1993. Corresponding market shares are shown in Exhibits 4-4 through 4-10.

4.3.1 Original Sites

The demonstration began in May or June, 1991 for the four original sites. Thus, 1990 represents a baseline period for these hospitals, and 1991 is a transition period. Baseline volumes differed substantially among the four sites. In 1990, more than 600 Medicare bypass operations were performed in St. Joseph's Hospital in Atlanta, more than twice as many as at University Hospital in Boston and at St. Joseph Mercy Hospital in Ann Arbor. Only 131 operations were performed in Ohio State University Hospital, the lowest Medicare volume of any of the seven demonstration sites.

St. Joseph's Hospital in Atlanta experienced a 26 percent increase in the number of Medicare bypasses performed between 1990 and 1993, from 604 to 761 cases. Absolute counts of CABG patients may not indicate the relative position of the demonstration hospitals if the total volume of CABGs performed in the market changes across time. The total number of Medicare CABGs done in the Atlanta market rose 13 percent during this period, from 1,606 to 1,809. As a result, the large increase in CABGs for St. Joseph's, Atlanta, translated to a more modest increase in market share, from 38 to 42 percent. A chi-square test indicated that this change in market share was statistically significant ($p < 0.05$). For all three years, St. Joseph's Hospital in Atlanta had the highest volume of Medicare CABGs in the Atlanta market. Their major competitor was Emory University Hospital, which saw its Medicare bypass volume decrease from 501 cases in 1990 to 375 cases in 1993. In contrast, two of the competitors with smaller volumes in 1990, Crawford Long and Piedmont Hospital, experienced substantial volume increases by 1993.

A second demonstration hospital, St. Joseph Mercy, Ann Arbor, also experienced a large increase in volume between 1990 and 1993, from 284 to 443 cases. This 56 percent increase in volume translated to an increase in market share from 10 to 15 percent (significant, $p< 0.01$). The demonstration site's two highest volume competitors were William Beaumont and St. John's hospitals, both of which had fairly constant market shares between 1990 and 1993. In fact, the only hospital other than St. Joseph Mercy, Ann Arbor, to have its market share vary by more than 2.1 percent points between 1990 and 1993 was Detroit Osteopathic,

TABLE 4-2

MEDICARE BYPASS VOLUMES AND MARKET SHARES FOR DEMONSTRATION HOSPITALS AND THEIR COMPETITORS

Original Demonstration Sites	1990 Medicare CABGs	1990 Market Share	1991 Medicare CABGs	1991 Market Share	1992 Medicare CABGs	1992 Market Share	1993 Medicare CABGs	1993 Market Share
Atlanta								
St. Joseph's	**604**	**37.6%**	**692**	**38.6%**	**703**	**39.2%**	**761**	**42.1% #**
Emory University	501	31.2%	533	29.7%	478	26.6%	375	20.7%
Crawford Long	184	11.5%	199	11.1%	225	12.5%	255	14.1%
Grady Memorial	10	0.6%	19	1.1%	18	1.0%	17	1.0%
Piedmont	137	8.5%	172	9.6%	200	11.1%	249	13.8%
Georgia Baptist	170	10.6%	179	10.0%	171	9.5%	152	8.4%
Total	1,606	100.0%	1,794	100.0%	1,795	100.0%	1,809	100.0%
Boston								
University Hospital	**249**	**9.8%**	**242**	**8.9%**	**211**	**7.5%**	**223**	**7.9% #**
Mount Auburn	114	4.5%	130	4.8%	138	4.9%	133	4.7%
St. Elizabeth's	233	9.2%	205	7.6%	154	5.4%	166	5.9%
Massachusetts General	397	15.6%	395	14.6%	415	14.7%	456	16.1%
Beth Israel	254	10.0%	277	10.2%	261	9.2%	255	9.0%
Brigham & Women's	344	13.5%	348	12.9%	330	11.7%	368	13.0%
New England Medical Center	265	10.4%	285	10.5%	293	10.4%	257	9.0%
New England Deaconess	294	11.6%	325	12.0%	407	14.4%	400	14.1%
Lahey Clinic	75	2.9%	144	5.3%	188	6.6%	192	6.8%
Catholic Medical Center	319	12.5%	356	13.2%	431	15.2%	384	13.6%
Total	2,544	100.0%	2,707	100.0%	2,828	100.0%	2,834	100.0%
Columbus								
Ohio State University	**131**	**5.1%**	**125**	**4.6%**	**131**	**4.7%**	**149**	**5.4%**
University of Cincinnati	118	4.6%	190	7.1%	180	6.5%	136	4.9%
Riverside Methodist	582	22.8%	650	24.2%	674	24.2%	599	21.8%
Grant Medical Center	148	5.8%	156	5.8%	166	5.9%	192	7.0%
Mount Carmel	207	8.1%	238	8.8%	247	8.9%	295	10.7%
Medical College of Ohio	75	2.9%	62	2.3%	69	2.5%	78	2.8%
Miami Valley	165	6.5%	156	5.8%	190	6.8%	190	6.9%
University Hospital of Cleveland	138	5.4%	108	4.0%	134	4.8%	146	5.3%
Doctors Hospital	78	3.1%	72	2.7%	72	2.6%	82	3.0%
Cleveland Clinic	915	35.8%	933	34.7%	927	33.2%	883	32.1%
Total	2,557	100.0%	2,690	100.0%	2,790	100.0%	2,750	100.0%
Ann Arbor								
St. Joseph Mercy - Ann Arbor	**284**	**10.2%**	**306**	**10.8%**	**325**	**11.0%**	**443**	**15.1% #**
Sinai Hospital	198	7.1%	186	6.6%	128	4.3%	148	5.0%
St. Joseph Mercy	106	3.8%	118	4.2%	172	5.8%	157	5.4%
University of Michigan	207	7.5%	219	7.7%	209	7.1%	181	6.2%
Henry Ford	179	6.5%	143	5.1%	162	5.5%	166	5.7%
St. Joseph	112	4.0%	118	4.2%	127	4.3%	97	3.3%
Harper Hospital	220	7.9%	258	9.1%	267	9.1%	237	8.1%
Ingham Medical Center	275	9.9%	316	11.2%	352	11.9%	318	10.8%
William Beaumont	437	15.8%	394	13.9%	428	14.5%	438	14.9%
McLaren Regional	193	7.0%	243	8.6%	237	8.0%	235	8.0%
Detroit Osteopathic	86	3.1%	39	1.4%	0	0.0%	0	0.0%
St. John's	477	17.2%	489	17.3%	541	18.4%	513	17.5%
Total	2,774	100.0%	2,829	100.0%	2,948	100.0%	2,933	100.0%

TABLE 4-2

MEDICARE BYPASS VOLUMES AND MARKET SHARES FOR DEMONSTRATION HOSPITALS AND THEIR COMPETITORS

	1990		1991		1992		1993	
Expansion Demonstration Sites	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share
Portland								
St. Vincent	**393**	**43.6%**	**563**	**50.0%**	**562**	**48.8%**	**491**	**50.8% #**
Emanuel Hospital	60	6.7%	37	3.3%	72	6.3%	32	3.3%
University Hospital	26	2.9%	48	4.3%	20	1.7%	32	3.3%
Good Samaritan	279	30.9%	282	25.1%	316	27.4%	262	27.1%
Providence Medical Center	144	16.0%	195	17.3%	182	15.8%	149	15.4%
Total	902	100.0%	1,125	100.0%	1,152	100.0%	966	100.0%
Indianapolis								
Methodist	**352**	**28.4%**	**335**	**26.8%**	**372**	**28.0%**	**339**	**23.9% #**
Indiana University	94	7.6%	97	7.8%	115	8.7%	104	7.3%
St. Francis	170	13.7%	199	15.9%	181	13.6%	222	15.6%
Community Hospital	110	8.9%	115	9.2%	111	8.4%	106	7.5%
St. Vincent	512	41.3%	502	40.2%	548	41.3%	649	45.7%
Total	1,238	100.0%	1,248	100.0%	1,327	100.0%	1,420	100.0%
Houston								
St. Luke's	**686**	**33.5%**	**680**	**34.3%**	**622**	**32.0%**	**674**	**31.9%**
St. Joseph	185	9.0%	69	3.5%	82	4.2%	57	2.7%
Hermann	33	1.6%	82	4.1%	93	4.8%	84	4.0%
Bayshore	44	2.1%	43	2.2%	42	2.2%	55	2.6%
Memorial	156	7.6%	157	7.9%	167	8.6%	168	7.9%
Medical Center Hospital	70	3.4%	91	4.6%	92	4.7%	68	3.2%
Methodist	504	24.6%	467	23.5%	470	24.2%	648	30.6%
Memorial City	58	2.8%	66	3.3%	74	3.8%	63	3.0%
Humana	42	2.1%	50	2.5%	43	2.2%	36	1.7%
HCA Spring Branch	82	4.0%	60	3.0%	55	2.8%	53	2.5%
Houston Northwest	46	2.2%	57	2.9%	54	2.8%	68	3.2%
U. Texas - Galveston	62	3.0%	62	3.1%	60	3.1%	60	2.8%
Other	80	3.9%	101	5.1%	90	4.6%	84	5.3%
Total	2,048	100.0%	1,985	100.0%	1,944	100.0%	2,116	100.0%

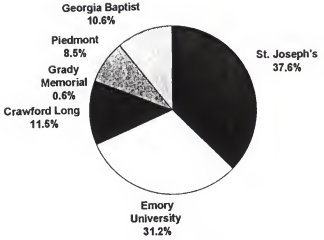
NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Within each market, the demonstration hospital is listed first and bolded.
3. Calendar year data. 1993 values are annual estimates, based on discharges through September 30th.
4. # indicates the demonstration hospital market share varied significantly across the four years ($p < 0.05$).
5. The original demonstration sites began the demonstration June 1991. The expansion demonstration sites began the demonstration June 1993.

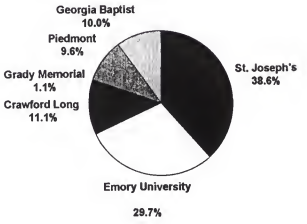
SOURCE: 1990, 1991, 1992 and 1993 MedPAR files.

EXHIBIT 4-4
MARKET SHARES OF DEMONSTRATION HOSPITAL AND COMPETITORS: 1990-93
ATLANTA

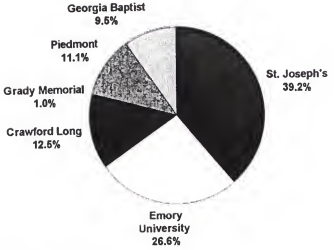
1990



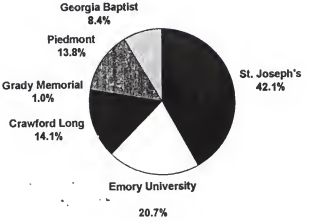
1991



1992

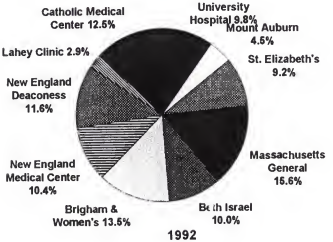


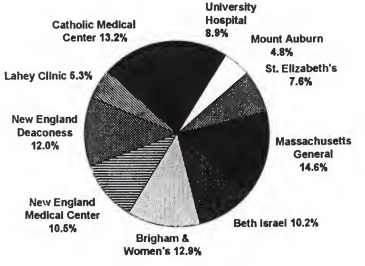
1993

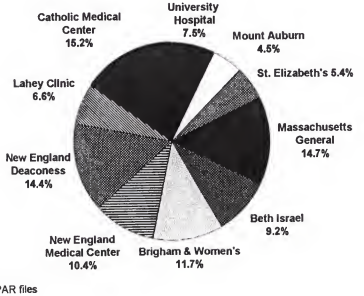


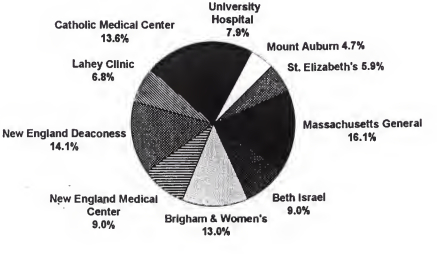
Source: 1990-93 MedPAR files

EXHIBIT 4-5
MARKET SHARES OF DEMONSTRATION HOSPITAL AND COMPETITORS: 1990-93
BOSTON





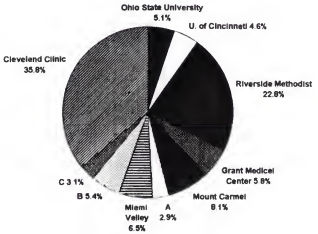




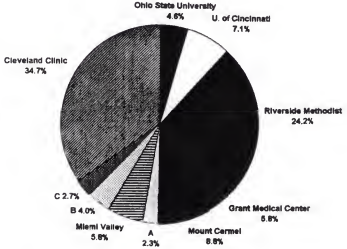
Source: 1990-93 MedPAR files

EXHIBIT 4-6
MARKET SHARES OF DEMONSTRATION HOSPITAL AND COMPETITORS: 1990-93
COLUMBUS

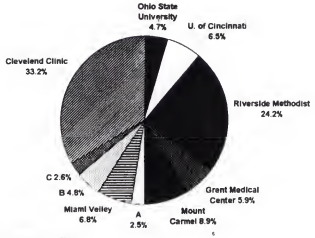
1990



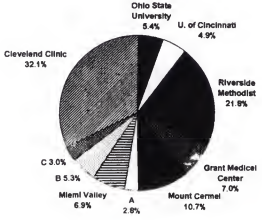
1991



1992



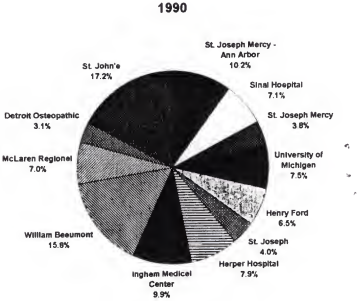
1993

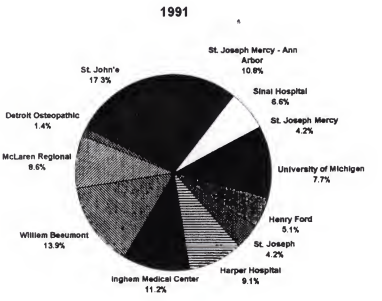


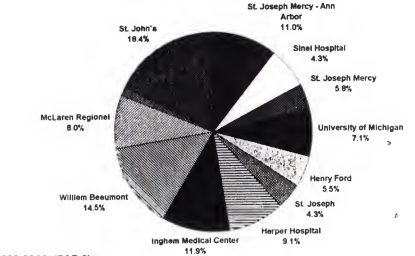
A Medical College of Ohio
B University Hospital of Cleveland
C Doctors Hospital

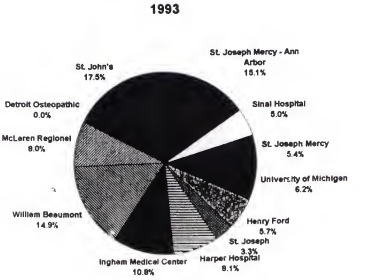
Source: 1990-93 MedPAR files

EXHIBIT 4-7
MARKET SHARES OF DEMONSTRATION HOSPITAL AND COMPETITORS: 1990-93
ANN ARBOR





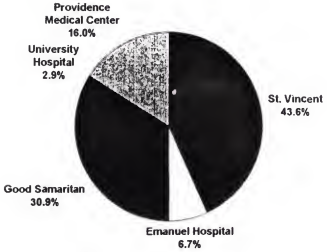




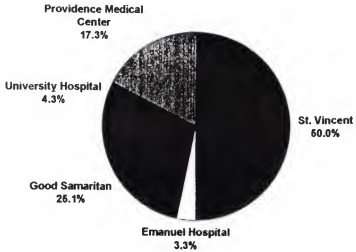
Source: 1990-93 MedPAR files

EXHIBIT 4-8
MARKET SHARES OF DEMONSTRATION HOSPITAL AND COMPETITORS: 1990-93
PORTLAND

1990



1991



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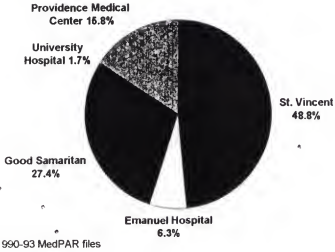
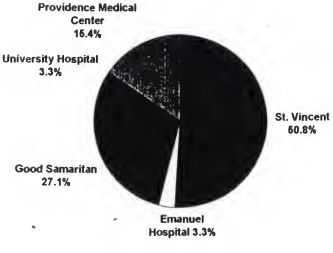


1993



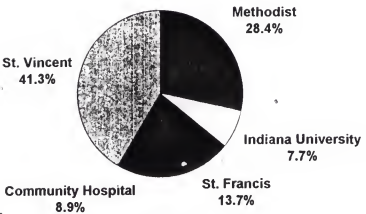
Source: 1990-93 MedPAR files

EXHIBIT 4-9

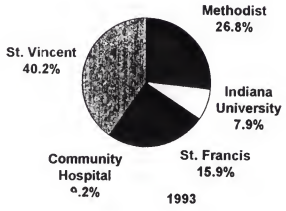
MARKET SHARES OF DEMONSTRATION HOSPITAL AND COMPETITORS: 1990-93

INDIANAPOLIS

1990



1991



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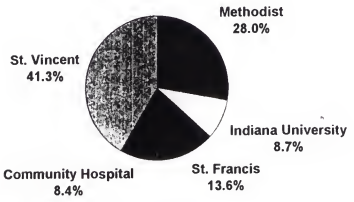
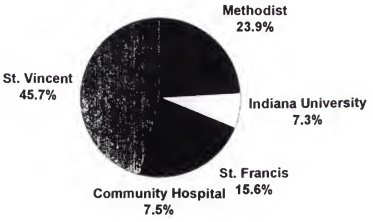


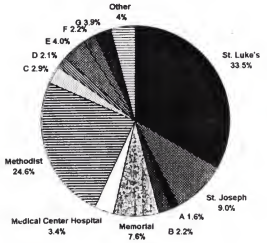
1993



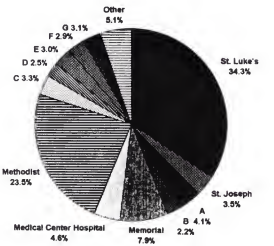
Source: 1990-93 MedPAR files

EXHIBIT 4-10
MARKET SHARES OF DEMONSTRATION HOSPITAL AND COMPETITORS: 1990-93
HOUSTON

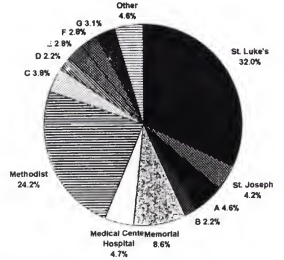
1990



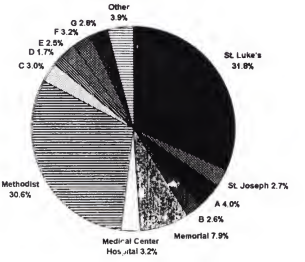
1991



1992



1993



A	Hermann
B	Bayshore
C	Memorial City
D	Humana
E	HCA Spring Branch
F	Houston Northwest
G	U. Texas-Galveston

Source: 1990-93 MedPAR files

which closed in 1991.

University Hospital in Boston experienced decreases in cases in 1991 and 1992, followed by an increase for 1993. This corresponded to a significant decrease in it's market share between 1990 and 1992 ($p < 0.01$) before recovering somewhat in 1993[1]. Nevertheless, its market share fell from nearly 10 percent to 7.9 percent between 1990 and 1993. University Hospital competes with other major teaching hospitals in Boston for CABG patients, especially Massachusetts General Hospital and Brigham and Women's that together control nearly 30 percent of the Boston Medicare market. Catholic Medical Center in Manchester, New Hampshire, also has a large share of the market. Although University Hospital considers Catholic Medical Center to be a competitor, it seems likely that Catholic Medical Center draws patients primarily from New Hampshire, rather than from the Boston metropolitan area. The two hospitals experiencing the largest growth in market shares were New England Deaconess, increasing from 11.0 to 14.1 percent of the market, and the Lahey Clinic, with Medicare bypass volumes increasing from only 75 in 1990 to 192 in 1993.

The fourth original demonstration site, Ohio State University Hospital, experienced virtually constant bypass volumes across the first three years, before growing 14 percent in 1993. This translated to a slight decrease in its market share from 1990-92 as the market grew 9 percent from 2,557 to 2,790 cases. However, Ohio State University recovered its original market share in 1993. Ohio State competes with hospitals in Columbus, Cleveland, Toledo, and Cincinnati for CABG patients. The market is dominated by the Cleveland Clinic and Riverside Methodist Hospital in Columbus. As a result, Ohio State's share of the market is only 5 percent; a figure that did not vary significantly across the four years. The hospital experiencing the largest growth in market share from 1990-93 was Mount Carmel whose Medicare bypass volume rose from 207 to 295. The largest decrease in market share was for the Cleveland Clinic. However, even as late as 1993, it controlled over 32 percent of the market.

4.3.2 Expansion Demonstration Sites

For the three hospitals beginning the demonstration in 1993, our data provide background information on volumes and market shares. St. Vincent's Hospital experienced a 43 percent increase in Medicare CABG volume between 1990 and 1991, from 393 to 563 patients (Table 4-2). Much of this increase resulted from an influx of Medicare HMO patients whose insurer contracted with St. Vincent's to provide bypass surgery. These patients typically have a very short stay at St. Vincent's and are then transferred to another short-term hospital. St.

[1]More recent data suggest continued recovery in CABG volumes at the hospital.

Vincent's Medicare CABG volume then remained virtually unchanged between 1991 and 1992, before declining over 10 percent in 1993, although its market share actually rose in a shrinking market. St. Vincent's Hospital had the largest market share in Portland for all three years. The market share rose from 44 percent in 1990 to 50 percent in 1991, as a result of the large increase in HMO volume. (Across the four years, its market share grew significantly, $p < 0.01$). None of its competitors experienced any substantial growth in volumes across the four years period.

Methodist Hospital in Indianapolis experienced fairly wide fluctuations in Medicare bypass volumes across the four years. The market share for Methodist Hospital in Indianapolis fell during the four year period, from 28.4 percent to 23.9 percent. In all four years, Methodist had the second largest market share among the five hospitals in Indianapolis offering CABG surgery. However, fluctuations in volumes at Methodist, coupled with volume increases at St. Francis and St. Vincent Hospitals, led to a lower market share for Methodist. This decrease is particularly noticeable for 1993, the first year of the demonstration at this site.

St. Luke's Hospital in Houston experienced a nine percent decrease in Medicare CABG volumes between 1990 and 1992, followed by an increase in 1993. Even following the decrease, more than 600 Medicare CABGs were performed in St. Luke's. St. Luke's in Houston also experienced a small decline in market share during the four-year period, although it maintained the largest market share for all four years, and the decrease was not statistically significant. St. Luke's and Methodist Hospital dominated the Houston market, with a combined market share of roughly 60 percent in each year. However, Methodist's share of the market rose from 24.2 percent in 1992 to 30.6 percent in 1993, while St. Luke's was declining. Five hospitals in Houston had market shares of less than 2 percent, and another eight had market shares of less than 5 percent in each of the three years. Thus, although many hospitals appear to be competing with St. Luke's for heart surgery patients, most have had little success attracting patients away from this major heart center.

4.3.3 Volume Trends by Quarter

To gain a better understanding of how the demonstration affected volumes, Table 4-3 presents Medicare discharges per quarter during the four-year period. For the original demonstration sites the first six quarters are pre-demonstration while the last nine quarters are post-demonstration. No immediate effect of the demonstration on volumes is apparent. There is substantial variation in volumes by quarter across all sites, with no readily apparent trend in the two quarters after the demonstration began versus the earlier quarters. Comparing total volumes for the four quarters before and after the demonstration began, two sites (St. Joseph's

TABLE 4-3

MEDICARE BYPASS VOLUMES AT DEMONSTRATION HOSPITALS, BY QUARTER, 1990-93

	1990				1991				1992				1993		
	Jan.-Mar.	Apr.-Jun.	Jul.-Sep.	Oct.-Dec.	Jan.-Mar.	Apr.-Jun.	Jul.-Sep.	Oct.-Dec.	Jan.-Mar.	Apr.-Jun.	Jul.-Sep.	Oct.-Dec.	Jan.-Mar.	Apr.-Jun.	Jul.-Sep.
	PRE-DEMONSTRATION						POST-DEMONSTRATION								
Original Demonstration Sites															
St. Joseph's of Atlanta	133	156	147	168	174	192	154	172	184	183	163	173	202	220	150
University Hospital-Boston	59	67	62	61	55	58	56	73	71	51	58	31	52	61	55
Ohio State U. Hospital	33	42	23	33	32	33	34	26	31	31	36	33	36	44	32
St. Joseph Mercy	61	65	81	77	66	79	74	87	88	68	79	90	103	122	108
Expansion Demonstration Sites															
	PRE-DEMONSTRATION														POST-DEMONSTRATION
Methodist of Indiana	67	103	79	103	58	104	77	96	93	94	108	77	74	92	89
St. Vincent's of Portland	98	100	90	105	131	146	136	150	138	153	132	139	126	129	114
St. Luke's	119	168	196	203	177	193	151	159	177	173	140	132	190	161	156

NOTES

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19
2. Calendar year data

SOURCE: 1990, 1991, 1992 and 1993 MedPAR Data

Hospital in Atlanta and Ohio State) experienced volume increases of less than two percent, while the other two sites experienced volume increases of 5-7 percent. It is not until 1993 that a trend becomes more readily apparent. The first two quarters in 1993 were the only quarters during which St. Joseph's Hospital in Atlanta performed more than 200 Medicare bypasses, although the hospital did do 192 in the quarter just prior to the demonstration. St. Joseph Mercy increased its volume to more than 100 bypasses during each of the first three quarters of 1993, compared with 79 in the quarter prior to the demonstration. In contrast, the 1993 quarterly volumes for Ohio State Hospital and University Hospital in Boston look quite similar to those in pre-demonstration quarters.

Data were available for only one quarter under the demonstration in the expansion sites. Thus, it is impossible to draw any conclusions regarding the effects of the demonstration on volume trends. The most noticeable feature of this baseline data is the large swings in volumes across quarters. For instance, Methodist Hospital in Indianapolis performed 103 surgeries the fourth quarter of 1990, followed by 58 and 104 cases in the first two quarters of 1991. These large swings are not unique to Methodist Hospital, however. For example, in 1992 the highest quarter volume at University Hospital was more than twice as large as the smallest volume, and quarterly volumes at Methodist, St. Joseph Mercy and St. Luke's all varied by more than 30 percent. Although three of these hospitals experienced their lowest volume quarter at the end of the year, that pattern does not hold for other years.

4.4 Distribution of Patients by DRG

Table 4-4 presents the distribution of cases by DRG for 1990-93 at each of the demonstration sites and their competitors. The national average proportions for DRGs 106, 107, and 108 are presented in the top row for comparison. Recall that DRG 106 is bypass with catheterization while DRG 107 is bypass without catheterization. A high percentage of patients in DRG 107 would be indicative of a referral hospital for patients who have already had their angiography performed elsewhere.

Three sets of chi-square tests for homogeneity of proportions (SAS Institute, 1990) were conducted to test statistically for differences in proportions. First, for each of the demonstration hospitals, we tested whether the distribution of patients had changed significantly across the four-year period. Second, we tested for homogeneity of proportions across the seven demonstration sites for each of the four study years. Third, we tested for homogeneity of proportions between each demonstration hospital and its competitors. Given local variations in practice patterns and population demographics, this comparison is likely to

TABLE 4-4

DISTRIBUTION OF MEDICARE BYPASS PATIENTS IN DEMONSTRATION HOSPITALS AND THEIR COMPETITORS BY DRG, 1990-1993

	1990			1991			1992			1993		
	DRG 106	DRG 107	DRG 108	DRG 106	DRG 107	DRG 108	DRG 106	DRG 107	DRG 108	DRG 106	DRG 107	DRG 108
National Proportions	49 %	36 %	15 %	57 %	39 %	4 %	57 %	40 %	3 %	57 %	39 %	4 %
Atlanta												
St Joseph's	26	59	16	31	63	6	30	63	7	25	70	5 #
Competitors	43	51	6 *	44	54	2 *	46	52	2 *	46	52	2 *
Boston												
University Hospital	35	53	12	47	48	5	36	59	5	37	61	2 #
Competitors	38	46	15	49	48	4	47	50	3 *	44	49	7 *
Columbus												
Ohio State U	45	45	10	57	39	4	56	41	3	61	37	2 #
Competitors	40	46	14	44	51	5 *	44	53	3 *	48	50	2 *
Ann Arbor												
St Joseph Mercy	44	39	18	49	45	5	45	53	2	59	36	5 #
Competitors	32	56	12 *	39	58	3 *	39	58	3 *	41	53	6 *
Portland, OR												
St Vincent's	42	40	18	38	56	6	38	58	3	39	56	4 #
Competitors	31	48	21 *	42	51	6	42	53	5	48	47	5 *
Indianapolis												
Methodist	49	32	19	62	31	7	55	39	6	52	36	12 #
Competitors	54	32	14	60	35	5	55	42	3 *	55	41	4 *
Houston												
St Luke's	42	42	16	48	37	15	47	49	4	47	46	7 #
Competitors	48	35	17 *	61	33	5 *	67	30	3 *	54	33	13 *

NOTES.

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36 10-36 15 or 36 19
2. Calendar year data 1993 values are based on discharges through September 30th.
3. Competitors is an average of all hospitals doing bypasses in market excluding the demonstration hospital
4. *Sets of demonstration site/competition proportions that are significantly different (p<0.05)
5. #Demonstration site proportions that are significantly different across the four years (p<0.05)

SOURCE 1990, 1991, 1992 and 1993 MedPAR files

be more meaningful than the comparison across demonstration sites.

The ability of the chi-square test to detect significant differences in proportions depends on two factors: the difference in the proportions and the sample sizes. It is important to bear this in mind given that we only report the proportions and not DRG frequencies (to reduce the size of the tables). The natural tendency is to assume that a larger difference in proportions is more likely to be significant than a smaller difference, but greater variability due to small samples may produce statistically insignificant results even for large differences.

The proportion of patients by DRG varied significantly ($p < 0.01$) across time in each of the seven demonstration sites (noted by the # symbol at far right). This result is not surprising given the change in coding between 1990 and 1991 that reduced the number of cases in DRG 108 nationally. The proportion of patients by DRG also varied significantly within each year across the seven demonstration hospitals (no symbol on table). For example, in 1993, 70 percent of the CABG patients in St. Joseph's Hospital in Atlanta were in DRG 107, indicating a very high percentage who had been referred to the hospital after their angiography was completed. University Hospital in Boston also has a very high percentage of patients in DRG 107. In contrast, in 1993, fewer than 40 percent of bypass patients were in DRG 107 for Ohio State University Hospital, St. Joseph Mercy, and Methodist of Indianapolis. The distributions of cases by DRG in these three hospitals are similar to the national proportions, indicating less of a referral-based practice than is found in the other demonstration sites.

Perhaps the most meaningful comparison is the test of each demonstration hospital's DRG casemix against that of its local competitors. Three sites had statistically different DRG proportions than their competitors in all four study years (as noted by the * symbol). St. Joseph's, Atlanta, and St. Luke's, Houston, had a higher percentage of referral patients in DRG 107 than their competitors, while St. Joseph Mercy, Ann Arbor, had a lower percentage of patients in DRG 107 compared to its competitor hospitals. Neither of the two other original demonstration sites, University Hospital or Ohio State Hospital, differed significantly from their competitors in 1990, the year before the demonstration began. However, Ohio State University Hospital's DRG mix differed significantly from its competitors in the three succeeding years, showing a lower percentage of referral cases in DRG 107. University Hospital in Boston differed from its competitors in 1992 and 1993, treating a higher percentage of patients in DRG 107.

Thus, there is no consistent pattern across the demonstration sites. Of the four original sites, two tend to treat a high percentage of bypasses with catheterization while the other two treat a low percentage relative to their competitors. In addition, the two hospitals that changed their DRG casemixes during the demonstration, relative to their competitors, did so in opposite

directions, with one increasing and the other decreasing its proportion of referral-based bypasses without catheterization.

4.5 Demographic Characteristics of Demonstration vs. Competitor Cases

Hospital payments for bypass surgery under the demonstration do not vary within DRG; however, the severity of patient illness does vary within DRG. Thus, hospitals have an incentive to "cream skim" by treating only the less seriously ill patients who require fewer resources and have a greater likelihood of a short stay and good outcomes. The MedPAR claims files do not contain the level of clinical data necessary to fully adjust for patient severity. They do, however, contain two demographic variables that may serve as rough indicators of whether a hospital is treating patients that vary systematically from those treated by its competitors. The risk of death increases with increasing age, ceteris paribus, as shown below in Chapter 7. Within the Medicare population, a hospital treating a higher proportion of "younger" patients would generally be treating patients who were less severely ill than a hospital treating a high proportion of "older" patients. To test for differences in the age distribution of patients, we classified Medicare bypass recipients into three categories: under age 65, age 65-74, and age 75 and over, and conducted chi-square tests on the proportion of patients by category.

Female patients are generally poorer surgical candidates due to their smaller blood vessels. For this reason, we tested for differences in the proportion of patients by gender to determine if any hospital is treating a disproportionately larger fraction of males. We also tested for systematic differences in hospitals by race of patients.

Tables 4-5 presents the distribution of Medicare CABG recipients by age in the seven demonstration hospitals and their competitors. Chi-square tests reveal that the proportions of patients in the three age categories do not vary significantly across the demonstration hospitals in 1990. However, for the three later years they do vary significantly ($p < 0.05$) across the demo sites. It appears from the table that the differences in age distributions across the seven demonstration sites may reflect differences across the seven markets (demonstration hospitals and competitors combined). For example, in 1993, hospitals in the Atlanta and Columbus markets treated a higher percentage of patients under sixty five years of age than was the case in the other five sites. Thus, the Atlanta and Columbus demonstration sites appear to treat an age distribution of patients that more closely resembles their local competitors than other demonstration sites.

To determine whether the demonstration hospitals were treating a different age mix of

TABLE 4-5

DISTRIBUTION OF MEDICARE BYPASS PROCEDURES IN DEMONSTRATION HOSPITALS AND THIER COMPETITORS, BY AGE, 1990-93

	1990			1991			1992			1993		
	Under 65 Years	65-74 Years	Over 74 Years	Under 65 Years	65-74 Years	Over 74 Years	Under 65 Years	65-74 Years	Over 74 Years	Under 65 Years	65-74 Years	Over 74 Years
Atlanta												
St. Joseph's	8 %	67 %	25 %	11 %	64 %	25 %	10 %	63 %	27 %	11 %	67 %	22 %
Competitors	11	66	23 *	12	64	24	9	61	30	14	63	23
Boston												
University Hospital	7	65	29	5	62	33	6	58	36	8	66	26
Competitors	6	66	29	6	62	32	5	63	32	7	62	31
Columbus												
Ohio State University	13	67	20	14	60	26	15	66	19	12	62	26
Competitors	11	69	20	9	66	27	8	65	26 *	10	65	25
Ann Arbor												
St. Joseph Mercy	10	68	22	6	69	25	4	69	26	5	65	30 #
Competitors	8	66	26	7	65	28	7	65	28	6	65	29
Portland, OR												
St. Vincent	6	66	29	6	64	30	5	65	30	5	63	32
Competitors	9	64	26 *	8	64	28	7	66	27	5	65	30
Indianapolis												
Methodist	11	66	23	8	62	30	13	63	24	5	69	26 #
Competitors	9	69	22	9	67	24	9	64	27	8	68	24
Houston												
St. Luke's	9	67	24	9	67	24 *	8	68	25	7	66	27
Competitors	9	65	26	8	70	22 *	7	66	27	9	69	22

NOTES.

1 Includes all heart bypass operations, defined as DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36 10-36 15 or 36 19

2 Calendar year data 1993 data are based on discharges through September 30th

3 Competitors is an average of all hospitals doing CABGs in markets excluding demonstration hospital

4 *Sets of demonstration site/competition proportions that are significantly different (p<0 05)

5 #Demonstration site proportions that are significantly different across the four years (p<0 05)

SOURCE 1990, 1992, 1992 and 1993 MedPAR files

patients than the local competition, we performed chi-square tests on each demonstration/competitor pair in each year. Although four pairs of proportions were significantly different, no demonstration hospital was different from its competitors in more than one year. This would indicate that differences in proportions by age group are a function of geographic differences in demographic patterns across the country rather than demonstration hospitals attracting a unique age mix within their own markets.

Tests for homogeneity of proportions for each demonstration site across the four years showed significant trends for St. Joseph Mercy in Ann Arbor and Methodist Hospital in Indianapolis. St. Joseph Mercy experienced an increase in patients over age 74 (from 22 to 30 percent) while Methodist experienced up-and-down fluctuations in this percentage. However, neither hospital treated an age distribution that was different from its market in any year, indicating that the hospital may merely be following a more general market trend.

Table 4-6 presents the proportion of bypasses performed on males in the demonstration hospitals and markets. As is the case nationally, roughly two-thirds of bypass recipients are male. However, this proportion varies significantly among the seven demonstration hospitals (at the 5 percent level) for all years except 1992. (In 1992 the proportion varies significantly at the 10 percent level.) The proportion of male patients ranges from a high of 72 percent in St. Luke's in 1990 and 1993 to a low of 59 percent in Ohio State University Hospital in 1993.

The proportion of males treated in St. Joseph's Hospital in Atlanta, Ohio State University, and St. Vincent's are never statistically different that the proportions for their competitors. No hospital differs from its competitors for more than two years, and no hospital differs from its competitors only after the demonstration started.

Table 4-7 presents similar distributional statistics by race of CABG recipients, using three categories: white, black, and other (which includes patients coded either as "other" or "unknown" on the MedPAR files). The seven demonstration sites differed significantly in their proportions of patients by race for all four years. This is not surprising given the different geographic locations of the hospitals, and the different racial compositions of the populations in the market areas.

Three demonstration sites, Ohio State in Columbus, St. Vincent's in Portland and St. Luke's in Houston, never varied significantly in the racial composition of their patients versus their competitors, and University Hospital in Boston differed from its competitors only in 1990. In the three remaining sites, there are significant differences in the racial composition of patients between the demonstration sites and the competitors. Both St. Joseph's Hospital in Atlanta and St. Joseph Mercy in Ann Arbor treated a higher percentage of whites than their competitors, while Methodist treats a higher percentage of blacks. These differences can, at

TABLE 4-6

PROPORTION OF MEDICARE BYPASS PROCEDURES ON MALES IN DEMONSTRATION HOSPITALS, 1990-93 AND THIER COMPETITORS

	1990	1991	1992	1993
Atlanta				
St. Joseph's	65 %	65 %	69 %	65 %
Competitors	67	67	67	66
Boston				
University Hospital	65	60	60	63
Competitors	66	66 *	67 *	65
Columbus				
Ohio State University	70	63	65	59
Competitors	68	66	67	66
Ann Arbor				
St. Joseph Mercy	69	70	71	65
Competitors	65	73 *	65 *	65
Portland, OR				
St. Vincent	69	70	70	69
Competitors	69	72	70	64
Indianapolis				
Methodist	60	60	66	70 #
Competitors	64	68 *	65	67
Houston				
St. Luke's	72	71	68	72
Competitors	67 *	68	68	64 *

NOTES:

1. Includes all heart bypass operations, defined as DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 data are based on discharges through September 30th.
3. Competitors is an average of all hospitals doing bypasses in markets excluding demonstration hospital.
4. *Sets of demonstration site/competition proportions that are significantly different ($p<0.05$).
5. #Demonstration site proportions that are significantly different across the four years ($p<0.05$).

SOURCE: 1990, 1991, 1992 and 1993 MedPAR files.

TABLE 4-7

DISTRIBUTION OF MEDICARE BYPASS RECIPIENTS IN DEMONSTRATION HOSPITALS AND THEIR COMPETITORS, BY RACE, 1990-93

	1990			1991			1992			1993		
Original Demonstration Sites	White	Black	Other	White	Black	Other	White	Black	Other	White	Black	Other
Atlanta												
St. Joseph's	*93*	*2*	*5*	*93*	*2*	*5*	*91*	*4*	*5*	*90*	*4*	*6*
Competitors	*90*	*6*	*4* *	*89*	*7*	*4* *	*88*	*6*	*4* *	*87*	*8*	*5* *
Boston												
University Hospital	*94*	*2*	*4*	97	1	2	94	4	2	95	2	3
Competitors	*96*	*1*	*3* *	96	1	3	94	4	2	95	1	4
Columbus												
Ohio State University	89	4	7	91	3	6	94	2	4	94	3	3
Competitors	93	3	4	92	3	5	92	3	5	91	3	6
Ann Arbor												
St. Joseph Mercy	*99*	*1*	*0*	*96*	*2*	*2*	93	3	4	*95*	*2*	*3*
Competitors	*90*	*7*	*3* *	*90*	*7*	*3* *	91	6	3	*89*	*8*	*3* *
Expansion Demonstration Sites												
Portland, OR												
St. Vincent's	94	1	5	93	1	6	94	1	5	91	1	8
Competitors	94	1	5	92	1	7	91	1	8	89	1	10
Indianapolis												
Methodist	*87*	*8*	*5*	*89*	*6*	*3*	*89*	*7*	*4*	*91*	*4*	*5*
Competitors	*94*	*1*	*5* *	*94*	*2*	*4* *	*93*	*2*	*5* *	*93*	*2*	*5* *
Houston												
St. Luke's	91	4	5	90	3	7	88	4	6	90	5	5
Competitors	89	5	6	88	6	6	88	6	6	86	7	7

NOTES:

1. Includes all heart bypass operations, defined as DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36 10-36 15 or 36 19
2. Calendar year data 1993 data are based on discharges through September 30th
3. Other includes patients codes as "other" or "unknown."
4. Competitors is an average of all hospitals doing bypasses in market excluding demonstration hospital
5. *Sets of demonstration site/competitor proportions that are significantly different ($p < 0.05$)
6. #Demonstration site proportions that are significantly different across the four years ($p<0.05$)

SOURCE: 1990-1993 MedPAR files

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least in part, be attributable to hospital location, even within its own market. For instance St. Joseph Mercy has several competitors in Detroit which has a larger black population than does Ann Arbor.

4.6 Length of Stay Trends

Table 4-8 presents the average length of stay for each of the original demonstration hospitals versus their competitors. Nationally, the average length of stay for patients in DRG 107 (CABG without cardiac catheterization) is roughly three days shorter than for those undergoing CABG with catheterization in DRG 106. To standardize for differences in the number of patients in each DRG, hospital average length of stay by DRG was weighted by the national proportion of cases in each DRG. As was seen nationally, the general trend is towards shorter stays. For example, in Atlanta, the average length of stay at Saint Joseph's Hospital decreased 27 percent, from 12.3 to 9.0 days. The average length of stay for the Atlanta competitors decreased 18 percent, from 13.6 to 11.2 days. The average stay at University Hospital in Boston decreased by 5.7 days from 1990 to 1993, the largest decrease for any of our sites. By 1993, all of the demonstration sites except Ohio State University Hospital had shorter average stays than their competitors.

Using regression analysis, we tested whether the average length of stay differed significantly across the seven demonstration sites, adjusting for DRG mix. In each of the four years the F-value indicated significant differences ($p < 0.01$). We also used pooled regression analysis to test whether length of stay in each of the seven demonstration sites was significantly different from the set of all competitors (aggregated across all seven sites) in each of the four years. The results of these regressions are presented in Table 4-9. Stays in St. Joseph's Hospital in Atlanta and St. Vincent's were significantly shorter than in the competitors for all four years, with the differences ranging from 2.52 to 3.62 days. Stays in Methodist and St. Joseph Mercy were roughly 2 days shorter (and statistically different) than in the competitors for 1991-93. The particularly short stays in Atlanta and Portland imply a wider referral network with more frequent transfers to community hospitals post-discharge.

We also used regression analysis to test whether the start of the demonstration had affected the trend in length of stay at the four original demonstration sites. Each regression was performed using patient level data for each demonstration hospital and set of competitors. For this analysis, we constructed a variable "month" defined as one for January 1990, two for February 1990, and so forth, through 45 for September 1993. Length of stay was regressed on DRG (to adjust for casemix differences), demo (equal to one for the demonstration hospital),

TABLE 4-8

AVERAGE ADJUSTED LENGTH OF STAY FOR MEDICARE BYPASS PATIENTS IN DEMONSTRATION MARKETS

	1990	1991	1992	1993
Atlanta				
Saint Joseph's	12.3	11.3	10.2	9.0
Competitors	13.6	12.5	12.1	11.2
Boston				
University Hospital	17.6	13.8	12.9	11.9
Competitors	16.7	15.8	14.9	14.3
Columbus				
Ohio State U. Hospital	15.4	15.9	14.3	13.2
Competitors	14.6	13.6	12.9	12.4
Ann Arbor				
St. Joseph Mercy	14.2	12.1	11.4	10.7
Competitors	15.5	14.6	13.3	12.5
Portland, OR				
St. Vincent's	12.4	11.0	10.1	9.1
Competitors	9.9	10.6	10.1	9.9
Indianapolis				
Methodist	14.4	12.4	11.5	10.5
Competitors	15.4	13.5	12.7	12.2
Houston				
St. Luke's	14.7	13.7	12.7	11.5
Competitors	16.9	15.5	16.1	14.2

NOTES:

1 Includes all heart bypass operations, defined as DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19

2 Calendar year data. 1993 data are based on discharges through September 30th.

3 Adjusted to standardize for proportion of patients in each DRG.

4 Competitors is an average of all hospitals doing bypasses in markets excluding demonstration hospital

5. Data for St. Vincent's exclude HMO enrollees.

SOURCE: 1990, 1991 and 1992 MedPAR files

TABLE 4-9

RESULTS OF MEDICARE BYPASS LENGTH OF STAY REGRESSIONS FOR DEMONSTRATION HOSPITALS AND COMPETITORS, 1990-93

	1990	1991	1992	1993
Intercept	18.72 **	15.27 **	15.09 **	14.82 **
DRG 106	-2.46 **	0.58	-0.21	-0.70 **
DRG 107	-6.21 **	-3.60 **	-3.77 **	-4.15 **
St. Joseph's	-2.52 **	-2.74 **	-2.94 **	-3.05 **
University-Boston	1.42	-0.67	-1.20	-1.13
Ohio State	0.23	1.69 **	0.86	0.73
St. Joseph Mercy	-1.14	-1.96 **	-1.90 **	-2.21 **
St. Vincent's	-2.87 **	-3.30 **	-3.30 **	-3.62 **
St. Luke's	-0.49	-0.20	-0.65	-0.87 **
Methodist	-0.87	-2.03 **	-2.01 **	-2.32 **
R^2	0.03	0.05	0.03	0.06
F-test	49.38	85.54	49.28	78.92
No. of Observations	13,446	14,061	14,361	10,713

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th.
3. DRG 108 is the omitted category. All competitors for the seven demonstration hospitals is the omitted category.
4. **Statistically significant ($p<0.01$).
5. Data for St. Vincent's excludes HMO enrollees.

SOURCE: 1990-93 MedPAR and National Claims History files.

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and demo interacted with month. The coefficient on the month variable is negative and significant in all four regressions, as expected, see Table 4-10, indicating that lengths of stay have grown shorter in all four sites. The coefficient on the interaction of month and demo is statistically significant only for University Hospital in Boston. The coefficient on the month variable (-.117) implies a 3.2 day shorter stay in September, 1993, compared to June, 1991, for the competitor hospitals in Boston. The negative interaction coefficient implies a further reduction in stays of an additional 1.4 days for University Hospital patients.

Hospitals can achieve shorter average stays by shortening the stays for all patients, by shortening stays for patients in one DRG, or by eliminating extremely long stays. We present two types of statistics to illustrate how the distribution of lengths of stay have changed to achieve shorter average stays. First, for 1993 data, Exhibit 4-11 presents distributions of length of stay for each demonstration hospital and its competitors for DRG 106 and DRG 107. The two DRGs are presented separately since average stays vary by several days. (We do not present data on DRG 108, since it comprises less than 5 percent of all bypass cases.) To facilitate comparisons across different bypass volumes, the vertical axis measures proportion of patients, rather than number of patients.

The first two panels in Exhibit 4-11 present length of stay distributions for Saint Joseph's Hospital in Atlanta and its competitors. The mean length of stay in St. Joseph's Hospital in Atlanta is roughly two days shorter than its competitors' (Table 4-8). From the graphs it does not appear as though the tail ends of the distributions (indicating patients with very long stays) are substantially different for St. Joseph's Hospital in Atlanta and its competitors. Instead, it appears that St. Joseph's Hospital in Atlanta achieves its shorter average stays by discharging a higher percentage of patients with very short stays, particularly in DRG 106. While the two distributions are similar for DRG 107 (with St. Joseph's Hospital in Atlanta having a slightly higher proportion of patients with short stays), the graph for DRG 106 indicates many more patients with stays of 8 days or less in St. Joseph's. The next two sets of panels, for St. Joseph Mercy and Methodist Hospital exhibit similar patterns. The demonstration sites and their competitors have similar distributions for DRG 107, but the demonstration hospitals have noticeably more patients with short stays in DRG 106. Since patients in DRG 106 undergo catheterization during the same stay as the bypass, hospitals have the opportunity to aggressively shorten lengths of stay by reducing the waiting time between the two procedures. For example, hospitals could eliminate the scenario in which patients are admitted for the catheterization on a Thursday or Friday and then wait in the hospital until Monday for the bypass to be performed. It appears that these three demonstration sites have made such efforts to shorten stays in DRG 106. (See Chapters 10 and 11.)

TABLE 4-10

REGRESSION RESULTS ON TRENDS IN MEDICARE BYPASS LENGTH OF STAY AT ORIGINAL DEMONSTRATION HOSPITALS, 1990-93

	Atlanta	Boston	Columbus	Ann Arbor
Intercept	13.990 **	18.629 **	19.812 **	15.789 **
DRG106	-0.547	0.142	-2.578 **	0.569
DRG107	-2.929 **	-5.725 **	-6.010 **	-4.166 **
Demo	-1.414 **	-0.524	1.418	-1.462 **
Month	-0.076 **	-0.117 **	-0.052 *	-0.096 *
Month*Demo	-0.008	-0.052 *	0.002	-0.010
R^2	0.045	0.073	0.048	0.067
F-test	62.08	161.38	101.14	154.39
No. of Observations	6,518	10,175	9,990	10,726

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th.
3. DRG 108 is the omitted category.
4. **Statistically significant (p<0.01).
5. *Statistically significant (p<0.05).

SOURCE: 1990-93 MedPAR and National Claims History files.

EXHIBIT 4.11

LENGTH OF STAY DISTRIBUTIONS FOR MEDICARE DRG 106 AND DRG 107 PATIENTS IN DEMONSTRATION HOSPITALS AND COMPETITOR HOSPITALS, 1993

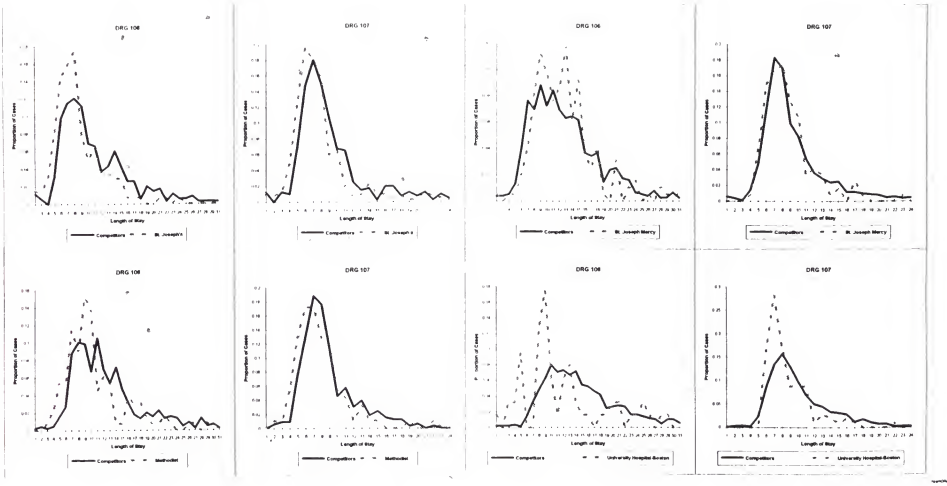
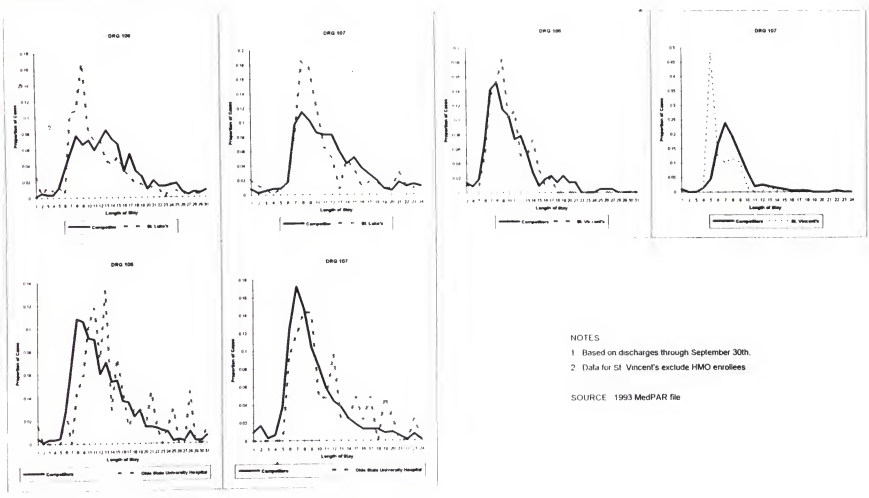


EXHIBIT 4-11(continued)

LENGTH OF STAY DISTRIBUTIONS FOR MEDICARE DRG 106 AND DRG 107 PATIENTS IN DEMONSTRATION HOSPITALS AND COMPETITOR HOSPITALS, 1993



NOTES

1 Based on discharges through September 30th.

2 Data for St. Vincent's exclude HMO enrollees

SOURCE 1993 MedPAR file

The fourth pair of distributions in Exhibit 4-11 present length of stay distributions for University Hospital in Boston and its competitors. The DRG 106 graph for University Hospital has an odd shape with many spikes, resulting from the relatively small number of cases treated at this site. DRG 107 shows a more regular distribution. It appears that University Hospital achieves a shorter average stay than its competitors through shorter stays in both DRG 106 and DRG 107. This is also the case for St. Luke's Hospital in Houston.

St. Vincent's Hospital and its competitors have two of the shortest average stays in our markets, at 9.1 and 9.9 days, respectively. The very short lengths of stay for this market are achieved by virtually eliminating patients with long stays. This aspect of the distribution is quite dramatic, especially when compared with a market such as Boston that has relatively long average stays.

The final pair of panels present the length of stay distributions for Ohio State University Hospital and its competitors. Ohio State is the only demonstration site with a longer average stay than its competitors. Once again, the relatively small volume of patients leads to irregular distributions of length of stay. However, it is clear that the long average stay at Ohio State can be largely attributed to the high proportion of patients with very long stays for both DRGs.

To further examine how lengths of stay have changed over time, Table 4-11 presents data on the distributions of lengths of stay in demonstration hospitals and their competitors, relative to national percentile thresholds. For each DRG in each year, we calculated the national thresholds of length of stay (in days) for which 10 percent of cases, 25 percent of cases, 50 percent of cases, up to 95 percent of cases which had shorter stays. We then calculated for each demonstration site the proportion of cases with equal or shorter lengths of stay and weighted by national DRG percentages to standardize casemixes. Using these percentage thresholds, we can examine whether hospitals are achieving shorter lengths of stay by eliminating patients with very long stays or by shortening stays across the entire range of patients.

Table 4-11 presents the distribution of lengths of stay in comparison to national percentile thresholds. For example, in 1990, the 50th percentile (median) threshold for DRG-adjusted Medicare bypass length of stay was 14 days. Among the demonstration and competitor hospitals, the proportion of cases with stays this length or shorter ranged from 47.4 percent in University Hospital, which had the longest average length of stay (17.6 days), to 87.0 percent in the Portland set of competitor hospitals, which had the shortest average length of stay (9.9 days). A similar comparison at the 75th percentile (18 days) indicates that only 67.2 percent of patients at University Hospital had been discharged within this period, while 95.8 percent of those in the Portland competitor hospitals had stays this length or shorter.

TABLE 4-11

DISTRIBUTION OF LENGTH OF STAY FOR MEDICARE BYPASS DEMONSTRATION HOSPITALS AND COMPETITORS, 1990-93

1990 National Percentile	Threshold Days	Atlanta		Boston		Columbus		Ann Arbor		Portland, OR		Houston		Indianapolis	
		Demo	Control	Demo	Control	Demo	Control	Demo	Control	Demo	Control	Demo	Control	Demo	Control
10%	9	32.9 %	22.5 %	14.0 %	11.1 %	13.9 %	19.4 %	18.3 %	14.1 %	21.2 %	49.0 %	13.6 %	12.3 %	24.0	14.8 %
25%	11	56.2	44.0	28.6	27.0	23.1	38.4	33.6	30.4	48.7	69.4	32.4	24.9	43.1	33.6
50%	14	75.1	67.3	47.4	50.2	58.0	63.3	58.0	54.2	77.9	87.0	62.4	47.5	61.4	56.7
75%	18	87.8	82.2	67.2	69.5	80.5	80.0	80.5	76.0	89.8	95.8	79.9	68.9	79.3	75.1
90%	25	94.2	91.9	85.7	87.8	91.0	90.1	91.0	90.1	94.3	98.1	92.7	87.5	92.0	88.9
95%	33	97.2	95.8	93.4	93.5	96.1	95.2	96.1	95.2	98.1	99.0	95.7	93.6	95.5	94.7
1991															
10%	9	36.6	22.5	16.5	9.5	11.2	18.4	17.8	14.7	21.5	33.7	9.6	9.5	26.2	15.3
25%	10	60.5	44.0	35.1	21.0	17.6	35.1	34.7	29.9	44.7	58.9	29.3	23.5	48.3	35.8
50%	13	80.7	61.4	64.1	49.9	39.2	63.9	70.6	56.6	79.7	82.9	63.2	49.7	71.1	62.8
75%	17	91.7	79.3	81.9	70.0	69.7	79.8	87.3	76.9	91.4	92.4	80.5	71.3	85.0	80.9
90%	24	95.9	92.0	92.8	87.3	90.0	91.8	97.7	90.5	98.4	96.3	91.8	87.7	94.0	92.1
95%	31	97.4	95.5	94.3	93.7	93.6	95.8	98.3	95.4	99.2	99.0	95.3	93.5	98.4	96.0
1992															
10%	9	47.6	26.6	15.3	13.4	12.1	21.8	26.5	21.2	28.6	45.9	13.5	10.7	33.8	23.9
25%	10	66.4	47.2	38.9	28.7	23.5	40.1	48.4	38.2	61.5	63.6	32.0	23.5	52.8	41.4
50%	12	49.3	64.4	62.9	46.9	42.9	58.4	72.6	55.3	79.6	78.4	54.2	41.3	71.0	30.7
75%	17	89.8	83.6	80.4	74.3	74.2	81.8	89.0	80.7	95.3	93.1	82.3	69.7	86.1	82.3
90%	24	95.0	93.3	92.9	89.6	92.5	92.3	95.3	92.4	97.3	97.1	93.7	87.2	94.4	92.6
95%	30	97.6	96.4	97.3	94.6	95.5	96.2	97.7	96.0	98.8	98.6	97.4	93.3	97.2	95.5
1993															
10%	8	51.8	33.2	16.5	11.3	12.9	20.9	25.4	20.3	23.4	32.7	19.4	13.3	35.5	23.7
25%	10	69.8	52.5	41.1	27.1	26.4	39.8	45.6	40.3	60.6	56.9	40.6	25.5	56.5	44.4
50%	12	82.4	67.2	62.1	45.8	48.7	58.6	67.5	57.9	81.5	79.2	61.5	42.0	75.6	63.6
75%	16	92.3	86.0	80.3	71.7	72.9	51.2	89.5	80.2	97.1	91.0	82.6	70.9	88.0	82.1
90%	23	96.8	93.8	92.4	88.9	87.8	92.8	97.0	93.1	100.0	97.9	92.8	88.5	95.4	93.5
95%	30	98.0	97.2	97.4	94.3	96.5	96.1	98.7	96.4	100.0	98.9	97.8	94.3	98.2	96.5

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19
2. Calendar year data. 1993 values are based on discharges through September 30th
3. Competitors is an average of all hospitals doing bypasses in market excluding the demonstration hospital
4. Lengths of stay are adjusted to standardize the proportion of patients in each DRG
5. Data for St. Vincent's Hospital excludes HMO enrollees

SOURCE: 1990-93 MedPAR and National Claims History files

heart\tables\TAB4-11.XLS\rvd

One of the more striking comparisons is that between the Atlanta and the Portland demonstration hospitals. In 1993, these two hospitals had the shortest average stays in our sample, at 9.0 and 9.1 days, respectively. However, they differed dramatically in the proportion of patients with very short stays. At St. Joseph's Hospital in Atlanta 51.8 percent of patients were discharged in eight or fewer days, over 15 percentage points more than the next closest site, i.e., Indianapolis. At St. Vincent's only 23.4 percent of patients were discharged in eight days or less, only the seventh highest percentage among the 14 sites. At the other end of the spectrum, the national 75th percentile threshold was 16 days in 1993 (down from 18 in 1990). At St. Joseph's, Atlanta, 92.3 percentage of patients had stays this length or shorter, while the comparable value for St. Vincent's is 97.1 percent of patients. Additionally, all of St. Vincent's patients had been discharged by Day 23, compared to only 90 percent nationally. Why St. Vincent's had no long-stay Medicare bypass patients is unknown and will be pursued in follow-up case study interviews.

5.0 IMPACT OF BUNDLED PAYMENTS ON THE NET PROGRAM COSTS TO MEDICARE AND BENEFICIARIES

5.1 Introduction

In this chapter, we present estimates of the savings to the Medicare program and to beneficiaries resulting from the demonstration. To calculate savings from the demonstration, two basic evaluation questions are addressed. First, what did the program pay under the demonstration at each site? Second, what would the program have paid out in lieu of the negotiated bundled inpatient payment at each site?

Savings are estimated using three spending definitions. The first, and narrowest, definition involves a direct comparison of demonstration global inpatient payments and the PPS and Part B payments that would have been made if there were no evaluation at each demonstration site. Total savings are calculated as the amount of the negotiated per case discount multiplied by the number of cases under the demonstration.

The second savings calculation considers outpatient and other institutional costs post-discharge in addition to the global payment for the bypass surgery. If demonstration hospitals shift care from the inpatient setting so that it can be billed separately from the bundled demonstration rate, inpatient savings will overestimate true savings for the bypass episode.

The third, and broadest, measurement of savings addresses the question "Did the program save money after considering volume shifts from non-demo to demo hospitals?" During the selection process, all candidates' bids were screened against the costs of other local hospitals performing CABGs. It is our understanding that the four original demonstration hospitals among the are low-cost providers in their own market area. Hence, any bias due to changing market shares may, in fact, overstate the gains HCFA could expect from a national program that might select more expensive hospitals in some cities.

The remainder of the chapter is organized in the following manner. Section 5.2 discusses the analytic approach taken to estimate savings. First, it discusses the quasi-experimental design of the evaluation, and then it describes the three measures of savings that are estimated. Section 5.3 describes the data and the methods used in constructing the savings estimates. Section 5.4 provides results of the analysis.

5.2 Methods and Data Sources

5.2.1 Quasi-experimental Design

This study uses a quasi-experimental design with each demonstration hospital matched to a control group. A simpler experimental design would have tested for changes

using pre- and post-demonstration data only from the demonstration sites themselves. However, many research questions demand additional information from non-demo sites, calling for a quasi-experimental design. For example, the question, "How did changes in market shares for the demonstration hospital affect the estimates of savings?" cannot be addressed without information on competitor volumes. Thus, the competitor hospitals naturally form the "control" group for addressing this question. Competitor hospitals were defined as all hospitals located within the same metropolitan statistical areas (MSAs) as the demonstration sites, plus any additional hospitals that the demonstration sites viewed as competitors. (See Chapter 4 for a detailed discussion of the competitor hospitals.)

The Medicare bypass demonstration now involves seven hospitals around the country. Four original sites started receiving bundled payments in May and June, 1991. Three "expansion" sites joined the demonstration in June 1993. For the original sites, we have over two years worth of post-demonstration data, from its start through September, 1993. For the expansion sites, we have only a few months of post-demonstration data. Thus, the savings estimates presented below are limited to the four original sites. Savings from the three expansion sites will be analyzed in the follow-up evaluation to be completed in 1997.

To calculate savings under the demonstration, both the actual payments made and the payments that would have been made in lieu of the demonstration must be estimated. Calculating the actual payments received under the demonstration is the more straightforward of the two, given that data on payments are available from HCFA. The issues that arise from calculating the payments that would have been made if the hospitals had not participated in the demonstration are discussed in Section 5.2.4 which describes the methodology for calculating savings.

5.2.2 Measures of Savings

5.2.2.1 Total Inpatient Savings

The first, and narrowest, measure of savings simply involves net inpatient program savings at the demonstration hospitals. It is defined as:

$$NS^1_{dt} = [NIPC_{dt} - P_{dt}]^*D_{dt}$$

where

NS^1_{dt} = net program savings in demonstration hospital, d, in year t due to just inpatient services only;

$NIPC_{dt}$ = expected net inpatient program outlays per discharge in lieu of the demonstration;

P_{dt} = the HCFA negotiated price in year t;

D_{dt} = the total number of demonstration CABG patients in the demo hospital in year t.

Inpatient program outlays in lieu of the demonstration are defined as

$$NIPC_{dt} = DRG_{dt} + OUT_{dt} + PT_{dt} + \Sigma\ P_{dmt}MD_{dmt}$$

where

DRG_{dt} = expected DRG 106 or 107 payment to the demo in lieu of the bundled payment;

OUT_{dt} = average CABG outlier payments;

PT_{dt} = average Part A passthroughs;

P_{dmt} = average physician allowables for the m-th service; and

MD_{dmt} = average quantity of inpatient physician services per CABG discharge in the demonstration hospital if the hospital had not participated.

Only Part A DRG, outlier, IME, and pass-through costs plus Part B inpatient physician costs would be counted.

This version of savings focuses strictly on government obligations. A second version includes beneficiary liability by adding the beneficiary component of the demonstration payment to the negotiated rate, P*, and the beneficiary inpatient deductible and copayment amounts for the bypass stay to NIPC.

Under the narrowest definition, estimated program gain or loss would depend strictly on whether the bundled negotiated price was below or above expected inpatient outlays under prospective payment. The figures in brackets would be on a per discharge basis so as not to confound gains with any volume changes. Total savings requires multiplying per case savings by total demonstration Medicare CABG volume. Any productivity and other efficiency gains due to volume increases would accrue to providers rather than to the program unless HCFA negotiated a sliding volume rate. Inflation would not be a problem because expected outlays in lieu of the demonstration (NIPC) are evaluated over the same period covered by the negotiated

rate. Also note the NIPC is not actual hospital costs per case but an estimate of yearly Medicare payments under the existing DRG system.

5.2.2.2 Total Inpatient Plus Ambulatory Savings

A broader definition of net Medicare savings (or costs) would consider outpatient and other institutional costs as well. Hospitals, and particularly physicians, will have greater incentives to discharge demonstration patients earlier with attendant follow-up care at home or in another facility, with additional bills submitted outside the demonstration. Hence, a broader measure of savings is defined as:

$$NS^2_{dt} = NS^1_{dt} + (NOPC_{do} - NOPC_{dt})^*D_{dt}$$

$$NOPC_{dt} = NIPC_{dot} + OPD_{dt} + SNF_{dt} + \Sigma\ P_{dot}MD_{dot} + DME_{dt} + HHA_{dt}$$

where

NS^2_{dt} = net savings including the difference between post-demonstration costs not covered by the negotiated price (i.e., $NOPC_{do}$ minus $NOPC_{dt}$);

$NIPC_{dot}$ = net inpatient program outlays for CABG patients treated in other hospitals after discharge from the demonstration hospital;

OPD_{dt} = total Part A outpatient costs per CABG discharge;

SNF_{dt} = total SNF costs per CABG discharge ;

$\Sigma\ P_{dot}MD_{dot}$ = total outpatient physician costs per CABG discharge;

DME_{dt} = total durable medical equipment costs per CABG discharge; and

HHA_{dt} = total home health costs.

If hospitals shift the site of care by discharging patients earlier, the term in parentheses will be negative and inpatient savings alone will overestimate total savings for the bypass episode.

5.2.2.3 Cost Impacts of Changes in Market Shares

The broadest measure of cost savings would include the first two measures plus any additional savings or losses that result from changes in the locus of surgery between demonstration and other competitor hospitals. It is calculated as:

$$NS^3_{dt} = NS^2_{dt} + [\Delta(1 - MS_{dt})^*NIPC^*_{ot} + \Delta MS_{dt}{}^*P_{dt}]^*D_{dt}$$

where

NS^3_{dt} = net total savings beginning with project inpatient discounts and including adjustments for both ambulatory cost differences and any differences due to shifts to a more or less expensive demonstration hospital;

ΔMS_{dt} = change in the demonstration's hospital's market share; and

$NIPC_{ot}$ = average net inpatient Medicare CABG outlays in local non-demonstration hospitals.

Since $\Delta(1 - MS) = -\Delta MS$, $NS^3_{dt} = NS^2_{dt} + [\Delta MS_{dt}(NIPC_{ot} - P_{dt})]^*D_{dt}$. Thus, $(NIPC_{dt} - P_{dt})$ can be interpreted as the savings per case shifted. The product of ΔMS_{dt} and D_{dt} provides the number of cases shifted, and the entire right-hand term is the change in costs after accounting for shifts away from competitor hospitals towards the demonstration hospital.

5.2.3 Data Sources

5.2.3.1 Negotiated Hospital Rates

HCFA provided the contractor with the negotiated demonstration rates for each hospital for 1991-93. These are presented in Table 5-1. The program liability is divided into two components, Part A and Part B. These correspond to the charges to each trust fund for demonstration patients. They do not indicate the split of the bundled payment between the hospital and the physicians, as this is determined within each hospital. Beneficiary liability is the amount paid by the patient in lieu of the normal (variable) inpatient deductible and physician/supplier copayments.

5.2.3.2 Claims Data

Claims data for this part of the evaluation come from two sources: HCFA's MedPAR and National Claims History data files. The goal of the file construction was to identify all

TABLE 5-1

NEGOTIATED PAYMENT RATES TO ORIGINAL BYPASS DEMONSTRATION HOSPITALS, 1991-93

	DRG 106				DRG 107			
	Part A Payment	Part B Payment	Beneficiary Liability	Total	Part A Payment	Part B Payment	Beneficiary Liability	Total
St. Joseph's - Atlanta								
1991	$21,432	$3,969	$992	$26,393	$18,457	$3,877	$969	$23,303
1992	21,465	3,975	994	26,434	20,877	2,437	609	23,923
1993	22,302	4,184	1,046	27,532	18,983	2,710	542	21,693
University Hospital - Boston								
1991	30,801	3,504	876	35,181	29,938	2,986	747	33,671
1992	30,804	3,505	876	35,185	30,737	3,066	766	34,569
1993	31,996	3,656	914	36,566	27,206	2,688	672	30,566
Ohio State University Hospital								
1991	23,972	2,384	596	26,952	18,697	1,916	479	21,092
1992	23,972	2,384	596	26,952	18,697	1,916	479	21,092
1993	23,972	2,384	596	26,952	18,697	1,916	479	21,092
St. Joseph Mercy - Ann Arbor								
1991	27,265	4,014	1,003	32,282	21,544	3,227	807	25,578
1992	27,558	4,057	1,014	32,629	22,352	3,348	837	26,537
1993	29,972	4,400	1,100	35,470	20,733	3,160	790	24,683

SOURCE: HCFA, Office of Research and Demonstrations.

claims for patients undergoing coronary bypass surgery, in DRG 106 or DRG 107 in the demonstration hospitals and their competitors. Patients included those discharged from January, 1990 through September, 1993. Since the demonstration began in mid-1991, the 1990 data provide a full year of baseline utilization. The September, 1993, cutoff ensured that 90 days of post-discharge utilization data would be available for all patients over the first two years of the demonstration.

The data for inpatient hospital stays and skilled nursing facility (SNF) stays come from the Medicare MedPAR claims files for 1990-93. File construction began with the national file containing all bypass patients, described in Chapter 2, that had been edited to remove duplicate or inconsistent cases. The first step in the file construction was to identify the demonstration hospitals and their competitors. Lists of competitor hospitals were constructed with the help of representatives of the demonstration hospitals, as described in Chapter 4. American Hospital Association data, which provides hospital name, was merged onto the MedPAR files using the Medicare Hospital Provider Number to identify these hospitals. Demonstration sites were identified by the same method. In addition, one of the original demonstration hospitals had been given a special provider number by HCFA to aid in the processing of bypass demonstration claims. HCFA provided the contractor with this special provider number, and these claims were also identified. After identifying all beneficiaries undergoing CABG surgery in the demonstration hospitals and their competitors, all of their other inpatient hospital and skilled nursing facility admissions for these individuals were extracted from the relevant files.

HCFA also provided the evaluator with files containing all NCH claims for Medicare beneficiaries discharged from any hospital for CABG surgery during the period January, 1990, through September, 1993. The data were acquired in two phases: 1990-92 data and 1993 data. Our first round of data included all claims processed during 1990 through 1992 for bypass patients discharged during this three-year period. A second round of data included all claims for the last four months of 1992 and all of 1993 for patients discharged from the hospital for CABG surgery January through September, 1993, as well as claims submitted in 1993 for patients having CABG during the last four months of 1992. The September 1993 cutoff eliminated censoring in the 90-day post-discharge period since all patients had at least 90 days post-discharge occurring in 1993.

These raw files contained millions of claims. These were first processed to remove duplicate or denied claims. Claims for patients in the demonstration and the competitor hospitals were identified using the patient Health Insurance Claims Numbers (HICNOs) identified from the MedPAR file. Thus, physician/supplier, outpatient department, and home health claims were added to the file containing institutional claims.

5.2.4 Construction of Cost Measures

This section describes the construction of the cost measures used in calculating the three measures of cost savings.

5.2.4.1 Inpatient-Only Savings

Construction of inpatient-only savings requires comparison of hospital and physician/supplier payments made under the demonstration with payments that would have been made for inpatient bypasses in lieu of the demonstration. Demonstration payments per case were constructed using the negotiated rates (described in Table 5-1), weighted by the proportion of cases in each DRG in the demonstration hospital, and updated annually by HCFA. Beneficiary liability was calculated as the negotiated Part B copayment plus the inpatient deductible (if owed) from the MedPAR files.

The hospital Part A charges for the inpatient stay constitute roughly 70 percent of the cost of the bypass episode (inpatient stay and 90 days post discharge). Fortunately, estimation of corresponding PPS expenditures per case in lieu of the demonstration is straightforward since hospitals receive a fixed amount per DRG that does not vary with changes in length of stay, type of treatment, or costs. Thus, this amount is insensitive to changes in physician practice patterns that might result from the demonstration.

There are two possible ways to compute the PPS payments to the demonstration sites for the inpatient stay in lieu of the demonstration negotiated rate. One approach is to use the relevant fields on the MedPAR files. A second approach is to calculate what the two DRG payments would have been using the DRG cost weights, PPS wage index, pass through amounts, etc., just as if there were no demonstration. In theory, both methods should produce the same results. However, given the millions of claims that are processed, there are likely to be some miscoded fields in the data, making the construction of values from the claims less accurate than the calculated rates. Hence, we used the second approach.

Estimating what would have been paid to physicians for the inpatient stay in lieu of the demonstration is more problematic. Physician/supplier outlays could be constructed using submitted claims. Outlier amounts from erroneous data (or missing claims) could be handled using data trims. A drawback of this approach is the potential for the demonstration to affect physician/supplier practice patterns of inpatient care. Thus, using the actual bills submitted may underestimate what would have been paid in lieu of the demonstration if physicians under the demonstration conserved on inpatient services under the bundled payment.

An alternative method for estimating physician/supplier outlays is to calculate what

would have been paid for a standard "package" of inpatient services, using the RBRVS payment amounts, adjusted appropriately to account for changes in payments across time and over geographic areas. Thus, it eliminates the problem of endogeneity that results from using actual bills submitted under the demonstration. The drawback of this approach is that it assumes all patients receive a standard set of services and does not allow care to vary based on patient severity or physician practice styles. For example, if demonstration hospitals' patients were sicker on average than patients receiving the standard services, the estimate of physician/supplier spending in lieu of the demonstration will be biased downwards. However, this approach still seems preferable to using actual physician/supplier charges that partially reflect cost-saving behaviors.

Beneficiary inpatient liability per case in lieu of the demonstration is calculated as the sum of the inpatient deductible plus 20 percent of physician/supplier charges for the inpatient stay. The inpatient deductible is a separate variable on the MedPAR file; the physician/supplier copayment was calculated directly as a percentage of estimated Part B liability.

The components of expenditures and savings were calculated separately for DRG 106 and DRG 107. Total expenditures and savings were then computed as a weighted average of the two, where the hospital proportion of cases in each DRG served as the weights.

5.2.4.2 Inpatient Plus Outpatient Savings

Calculation of outpatient savings requires calculation of two additional estimates: (1) actual charges, and (2) charges in lieu of the demonstration after the bypass discharge. We use a 90-day post-discharge cutoff which, although relatively short, should capture most of the care that was shifted from the inpatient stay to post-discharge. Use of a shorter post-discharge period also helps filter out care for conditions unrelated to the bypass.

Actual expenditures in the post-discharge period were calculated using Medicare claims. Outpatient department, physician/supplier services, and home health charges were aggregated for each individual. All beneficiaries with less than $1,000 in inpatient physician/supplier claims were dropped assuming these cases had incomplete claims (see Chapter 2). It is also likely that their post-discharge claims are also incomplete. Inpatient hospital and SNF payments were calculated from the MedPAR files as the sum of the "amount reimbursed" variable, including the base amount for the DRG, the PPS portion of capital payments, outlier payments, disproportionate share payments, and indirect medical education, and the "bill total per diem" variable that includes the pass-through portion of capital payments, bad debt, and other pass-throughs such as direct medical education from the MedPAR files.

Post-discharge costs in lieu of the demonstration were calculated using 1990 baseline outpatient data for each demonstration hospital. These costs were constructed in a manner identical to the construction of the actual post-discharge costs during the demonstration period. To estimate the trend in outpatient expenditures in lieu of the demonstration, we calculated the percentage change in post-discharge expenditures between the base period and each of the demonstration years for the sets of competitor hospitals. Base-period average post-discharge expenditures for the demonstration hospitals were then adjusted by these inflation factors to estimate expenditures over the demonstration period if there had been no demonstration. The competitor hospitals are a natural control group for this analysis and should reflect changes in local post-discharge practice patterns. However, growth in outpatient costs at the competitor hospitals may be particularly sensitive to outlier cases, given the small number of patients treated in any one market. Hence, update factors may be subject to unreasonable random variation. To test the sensitivity of the results to the choice of update factors, we also estimated demonstration post-discharge trend in lieu of the demonstration using national update factors based on outpatient data for all hospitals performing bypass surgery, as described in Chapter 2. These growth rates were 9.2 percent from 1990 to 1991, 20.9 percent from 1990 to 1992, and 24.9 percent from 1990 to 1993.

Estimates of post-discharge spending were calculated separately for the DRG 106 and 107 then averaged with the demonstration hospital's proportion of cases in the two DRGs serving as weights. This was done for ease of presentation.

This approach to calculating outpatient savings implicitly assumes that differences in actual versus estimated spending in lieu of the demonstration are caused by the demonstration. Another source of variation in actual spending, mentioned above, is random variation in patient post-discharge needs. Given the relatively small number of patients in some of the demonstration hospitals, a few seriously ill patients could increase average spending in any given year. Even assuming no change in patient severity, these hospitals may not have followed local or national trends in post-discharge spending if they had not participated in the demonstration. The fact that the hospitals applied to be in the demonstration indicates that they were interested in making their bypass surgery units more profitable. These hospitals may have been more aggressive in shortening stays and shifting care to the outpatient setting or to other facilities than the average hospital, even without the demonstration, but we cannot estimate what this shift would have been.

5.2.4.3 Savings Including Market Share Shifts

Calculation of savings from the demonstration including additional savings from changes in market shares requires calculation of inpatient payments to competitor hospitals

and overall market shares. Actual market shares were calculated as the demonstration hospital's fraction of total Medicare bypass cases in the market, as identified using the MedPAR files.

Net inpatient CABG outlays in non-demonstration hospitals were calculated as the sum of the "amount reimbursed" and "bill total per diem" variables from the MedPAR files, discussed above. Inpatient physician/supplier charges in non-demonstration hospitals were calculated from the NCH files. As before, patients with less than $1,000 in inpatient charges were dropped from computation of the means.

The demonstration hospital's market share in 1990 was assumed to be the market share it would have had in 1991-93 in lieu of the demonstration. Again, this is a strong assumption in that all the demonstration hospitals have indicated (by applying for the demonstration and during case study interviews) that they were interested in actively trying to increase their volumes and market shares. They may have accomplished this goal without being chosen as a demonstration hospital, but we have no way of evaluating how successful they might have been.

5.3 Comparative Costs of Demo Vs. Non-Demo Patients by Market Area

5.3.1 Bypass Inpatient Stay

Table 5-2 presents savings arising during the inpatient stay at the four demonstration sites. For each hospital, the payment that would have been made in lieu of the demonstration is divided into three components: the PPS hospital payment, the part B physician/supplier payment, and the beneficiary liability. Payment under the demonstration is divided into program liability and beneficiary liability. Savings per case are then calculated by subtracting the negotiated demonstration payment from the payment in lieu of the demonstration. Total savings per hospital are the product of savings per case and the number of demonstration CABGs performed.

Total inpatient savings in the four original sites from the start of the demonstration through the third quarter of 1993 totalled $15.9 million. Medicare program savings totalled $13.7 million and beneficiary savings totalled $2.2 million. Demonstration savings in 1991 (the demonstration covered roughly the last seven months of this year) totalled $4.0 million, and savings in 1992 totalled $7.2 million. Savings for the first three quarters of 1993 totalled $4.7 million, corresponding to an estimated savings of $6.2 million for the entire year.

In each year, Ohio State University Hospital generated the largest per case savings of the demonstration hospitals. Program savings ranged from $9,512 to $10,806 per case, while beneficiary savings per case ranged from $823 to $948. These were slightly larger than the per case savings at University Hospital, Boston and more than twice as large as those at St. Joseph's

TABLE 5-2

INPATIENT SAVINGS AT THE FOUR ORIGINAL HEART BYPASS DEMONSTRATION HOSPITALS: 1991-1993

	Jun-Dec 1991	Jan-Dec 1992	Jan-Sept 1993
FOUR ORIGINAL DEMONSTRATION SITES			
Total Program Savings	$3,556,472	$6,317,988	$3,844,225
Total Beneficiary Savings	512,737	905,949	817,433
Total Savings	4,069,209	7,223,937	4,661,658
St. Joseph's - Atlanta			
Payment in Lieu of Demonstration			
PPS Payment	19,367	21,218	18,860
Part B Payment	6,141	5,778	5,788
Beneficiary Liability	1,749	1,816	1 694
Total	**27,257**	**28,813**	**26,342**
Demonstration Payment			
Program Liability	23,132	23,622	22,691
Beneficiary Liability	1,191	1,104	921
Total	**24,323**	**24,727**	**23,612**
Program Savings per case	2,376	3,374	1,957
Beneficiary Savings per case	558	712	773
Total Savings per case	**2,934**	**4,086**	**2,730**
Number of cases	383	654	539
Total Savings	**1,123,722**	**2,672,244**	**1,471,470**
University Hospital- Boston			
Payment in Lieu of Demonstration			
PPS Payment	36,338	37,448	34,077
Part B Payment	6,526	6,129	6,076
Beneficiary Liability	1,753	1,644	1,654
Total	**44,616**	**45,220**	**41,808**
Demonstration Payment			
Program Liability	33,480	33,883	31,954
Beneficiary Liability	931	920	892
Total	**34,411**	**34,803**	**32,846**
Program Savings per case	9,384	9,694	8,199
Beneficiary Savings per case	822	724	762
T tal Savings per case	**10,206**	**10,418**	**8,961**
Number of cases	123	165	110
Total Savings	**1,255,338**	**1,718,970**	**985,710**

TABLE 5-2 (continued)

INPATIENT SAVINGS AT THE FOUR ORIGINAL HEART BYPASS DEMONSTRATION HOSPITALS: 1991-1993

	1991	1992	1993
Ohio State U. Hospital			
Payment in Lieu of Demonstration			
PPS Payment	27,581	28,486	27,101
Part B Payment	6,316	5,893	6,204
Beneficiary Liability	1,786	1,683	1,772
Total	**35,683**	**36,062**	**36,641**
Demonstration Payment			
Program Liability	23,711	23,573	23,793
Beneficiary Liability	838	860	933
Total	**24,549**	**24,432**	**24,725**
Program Savings per case	10,186	10,806	9,512
Beneficiary Savings per case	948	823	839
Savings per case	**11,134**	**11,629**	**10,351**
Number of cases	80	127	110
Total Savings	**890,720**	**1,476,883**	**1,138,610**
St. Joseph Mercy - Ann Arbor			
Payment in Lieu of Demonstration			
PPS Payment	25,775	25,809	26,698
Part B Payment	6,229	5,963	6,133
Beneficiary Liability	1,847	1,804	1,914
Total	**33,852**	**33,622**	**34,745**
Demonstration Payment			
Program Liability	27,948	28,211	30,169
Beneficiary Liability	1,116	1,128	1,203
Total	**29,064**	**29,339**	**31,371**
Program Savings per case	4,056	3,561	2,662
Beneficiary Savings per case	731	676	711
Total Savings per case	**4,787**	**4,237**	**3,373**
Number of cases	167	320	316
Total Savings	**799,429**	**1,355,840**	**1,065,868**

NOTE:

1. Includes all heart bypass operations in DRG 106 or DRG 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites. The 1991 data include only cases covered under the demonstration.
3. 1993 savings are based on discharges through September 30th.

SOURCE: 1991-93 MedPAR and NCH files. Negotiated Demonstration Rates reported in Table 5-1.

Hospital in Atlanta or St. Joseph Mercy. Although OSU had the smallest volumes of the four demo sites, its large discount per case resulted in extraordinary savings. Total Medicare savings at OSU were $890,000 in 1991, $1.5 million in 1992, and $1.1 million for the first three quarters of 1993. The bulk of the savings accrued to the Medicare program.

University Hospital in Boston is similar to OSU Hospital in that it offered relatively large per case savings but treated a relatively small number of patients. Program savings per case ranged from $8,199 to $9,694 across the three years. University Hospital would have had the highest payments in lieu of the demonstration among the four hospitals, as well as the highest demonstration payments. This is not surprising for a teaching hospital located in the high cost Boston metropolitan area.

In contrast, St. Joseph's Hospital in Atlanta had the smallest per case savings among the demonstration hospitals. St. Joseph's Hospital in Atlanta is a non-teaching hospital, located in a low-cost area of the country. As a result, its PPS payment in lieu of the demonstration is substantially lower than for the other three sites, e.g., more than $7,000 lower than that for OSU Hospital which provided the greatest per case savings. As a result of its low PPS payment, St. Joseph could not offer as large a discount as the teaching hospitals that had higher PPS payments. Despite its low per case savings, St. Joseph contributed the greatest total inpatient savings over the course of the demonstration (over $5 billion) because of its very high volumes.

Total savings at St. Joseph Mercy, Ann Arbor, totalled $799,429 in 1991, $1.4 million in 1992, and $1.1 million for the first three quarters of 1993. St. Joseph Mercy had the second largest volume among the four demonstration hospitals and the second smallest per case savings in each year.

5.3.2 Inpatient Stay plus Outpatient Expenditures

Table 5-3 presents Medicare program savings (or losses) during the 90 days following discharge from the bypass hospitalization. Savings per case were calculated as the projected expenditures in lieu of the demonstration less the actual expenditures for each of the demo hospitals. This number was multiplied by the volume of demonstration cases to give an estimate of total savings arising from changes in locus of service.

Total post-discharge savings across the four sites were $409,905 in 1991, $387,450 in 1992 and $407,911 in 1993. Thus, although changes in post-discharge spending were expected to decrease the estimates of total savings, they actually increased savings estimates by $1.2 million over the three years.

For two of the hospitals, St. Joseph's, Atlanta, and St. Joseph Mercy, Ann Arbor, actual expenditures in the period post discharge are always less than the projected expenditures, resulting in larger savings per case than implied by the inpatient savings. These

TABLE 5-3

NINETY DAY POST DISCHARGE SAVINGS AT THE FOUR ORIGINAL HEART BYPASS DEMONSTRATION HOSPITALS

	Jan-Dec 1990	Jun-Dec 1991	Jan-Dec 1992	Jan-Sept 1993
FOUR DEMONSTRATION SITES				
Total Post Discharge Savings		**$409,905**	**$387,450**	**$407,911**
St. Joseph's - Atlanta				
Projected Post Discharge Expenditures in Lieu of Demonstration				
Skilled Nursing Facility		$93	$141	$198
Hospital		2,279	2,495	2,685
Physician/Supplier		852	941	867
Home Health		272	254	303
Outpatient Department		103	125	93
Total		**3,600**	**3,956**	**4,146**
Actual Post Discharge Expenditures				
Skilled Nursing Facility	64	14	87	69
Hospital	2,093	1,380	2,156	1,940
Physician/Supplier	837	844	862	820
Home Health	255	281	351	402
Outpatient Department	103	120	103	105
Total	**3,353**	**2,653**	**3,560**	**3,337**
Post Discharge Savings/Loss per case		**947**	**396**	**809**
Number of cases		383	654	539
Total Savings		**362,701**	**259,168**	**435,790**
University Hospital - Boston				
Projected Post Discharge Expenditures in Lieu of Demonstration				
Skilled Nursing Facility		0	0	0
Hospital		3,291	3,569	3,872
Physician/Supplier		985	1,074	1,006
Home Health		699	636	801
Outpatient Department		253	302	230
Total		**5,227**	**5,581**	**5,909**
Actual Post Discharge Expenditures				
Skilled Nursing Facility	0	24	95	312
Hospital	2,995	3,205	4,443	4,521
Physician/Supplier	975	925	879	968
Home Health	624	735	634	596
Outpatient Department	246	258	216	207
Total	**4,841**	**5,146**	**6,267**	**6,605**
Post Discharge Savings/Loss per case		81	-686	-696
Number of cases		123	165	110
Total Savings		**9,967**	**-113,243**	**-76,523**

TABLE 5-3 (continued)

NINETY DAY POST DISCHARGE SAVINGS AT THE FOUR ORIGINAL HEART BYPASS DEMONSTRATION HOSPITALS

	Jan-Dec 1990	Jun-Dec 1991	Jan-Dec 1992	Jan-Sept 1993
Ohio State University Hospital				
Projected Post Discharge Expenditures in Lieu of Demonstration				
Skilled Nursing Facility		131	200	270
Hospital		1,776	1,913	2,113
Physician/Supplier		646	660	658
Home Health		81	77	104
Outpatient Department		166	203	158
Total		**2,801**	**3,053**	**3,304**
Actual Post Discharge Expenditures				
Skilled Nursing Facility	92	0	100	102
Hospital	1,607	3,533	2,003	3,351
Physician/Supplier	643	570	654	581
Home Health	70	118	79	422
Outpatient Department	159	284	316	193
Total	2,572	**4,504**	**3,153**	**4,648**
Post Discharge Savings/Loss per case		-1,703	-100	-1,345
Number of cases		80	127	110
Total Savings		**-136,279**	**-12,674**	**-147,917**
St. Joseph Mercy - Ann Arbor				
Projected Post Discharge Expenditures in Lieu of Demonstration				
Skilled Nursing Facility		0	0	0
Hospital		1,963	2,125	2,343
Physician/Supplier		660	701	670
Home Health		234	218	307
Outpatient Department		230	277	221
Total		3,088	**3,321**	**3,541**
Actual Post Discharge Expenditures				
Skilled Nursing Facility	0	39	42	71
Hospital	1,784	867	1,507	1,646
Physician/Supplier	654	581	628	632
Home Health	207	375	221	401
Outpatient Department	222	187	127	169
Total	2,868	**2,049**	**2,527**	**2,919**
Post Discharge Savings/Loss per case		**1,039**	**794**	**622**
Number of cases		167	320	316
Total Savings		**173,516**	**254,198**	**196,561**

NOTE:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites.
3. 1993 values are based on discharges through September 30th.
4. Projected expenditures were calculated by multiplying the demonstration hospital's 1990 expenditures by the national growth rate in post discharge spending for each year.
5. Savings estimates do not include beneficiary savings.

SOURCE: 1990-93 MedPAR and NCH files.

savings result primarily from lower-than-expected costs for re-hospitalization following discharge from the bypass stay. For St. Joseph's, Atlanta, the per case savings range from $947 in 1991 to $396 in 1992. These correspond to total savings in the post-discharge period of more than $250,000 in each year. The post-discharge savings at St. Joseph Mercy were even larger, ranging from a low of $622 per case in 1993 to a high of $1,039 per case in 1993.

University Hospital in Boston also has slightly lower actual than projected expenditures in 1991, however, the difference of $81 is inconsequential. In 1992 and 1993, actual expenditures exceeded projected expenditures by nearly $700. This difference results primarily from higher-than-projected costs for re-hospitalizations.

Only Ohio State University Hospital, with losses in post-discharge expenditures each year, shows evidence of a shift of care outside the hospital. The increase in expenditures is almost entirely due to increases for rehospitalizations following the original bypass surgery.

These results are surprising, since it was expected that inclusion of changes in post-discharge care would decrease the savings estimates from the demonstration. There are two reasons to question the accuracy of these estimates. First, our projected expenditures are based on applying national trend rates to 1990 baseline per case outpatient spending on demonstration hospital bypass patients. If these baseline rates are unusually high because of random variation, regression to the mean is likely, and our projected expenditures will be high, biasing our savings estimates upward. Calculating an average expenditure for multiple baseline years would have reduced this problem, but our data did not include any years prior to 1990. Second, costs during the demonstration are subject to a random component, and the differences across years may not be significant. If there is wide variation in post-discharge costs across patients, the presence (or lack) of a few outlier cases may affect average costs but not indicate meaningful differences. Statistical tests were conducted on pooled 1991-93 data to determine whether actual post-discharge expenditures were significantly different than the projected expenditures by site. The mean and variance for actual expenditures was calculated directly, while the mean and variance of projected expenditures was calculated based on the 1990 actual spending, updated to account for national trends. T-tests of pooled data for 1991-93 indicated that projected expenditures were significantly different than actual expenditures for only one site, Ohio State University Hospital. This was the only site showing post-discharge losses in each year, as was expected.

To test the sensitivity of these results to the use of national inflation factors for updating post-discharge expenditures, post-discharge savings were also estimated using inflation factors based on trends in competitor hospitals to update the demonstration hospital baseline values.

These results are summarized in Table 5-4. The use of market-specific update factors results in substantially higher savings estimates for St. Joseph's Hospital in Atlanta. For

TABLE 5-4

COMPARISON OF 90 DAY POST-DISCHARGE SAVINGS ESTIMATES CALCULATED USING MARKET AREA GROWTH RATES IN EXPENDITURES WITH THOSE CALCULATED USING NATIONAL GROWTH RATES

	Jun-Dec 1991	Jan-Dec 1992	Jan-Sept 1993
FOUR DEMONSTRATION SITES			
Total Post Discharge Savings			
Using Market Area Trends	$1,032,110	$1,287,553	$1,644,903
Using National Trends	409,937	387,174	408,093
St. Joseph's - Atlanta			
Post Discharge Savings per Case			
Using Market Area Trends	$2,150	$1,828	$2,761
Using National Trends	947	396	809
Total Post Discharge Savings			
Using Market Area Trends	823,450	1,195,512	1,488,179
Using National Trends	362,701	258,984	436,051
University Hospital - Boston			
Post Discharge Savings per Case			
Using Market Area Trends	968	-263	360
Using National Trends	81	-686	-696
Total Post Discharge Savings			
Using Market Area Trends	119,064	-43,395	39,600
Using National Trends	9,963	-113,190	-76,560
Ohio State University Hospital			
Post Discharge Savings per Case			
Using Market Area Trends	-1,775	-312	-1,288
Using National Trends	-1,703	-100	-1,345
Total Post Discharge Savings			
Using Market Area Trends	-142,000	-39,624	-141,680
Using National Trends	-136,240	-12,700	-147,950
St. Joseph Mercy - Ann Arbor			
Post Discharge Savings per Case			
Using Market Area Trends	788	547	819
Using National Trends	1,039	794	622
Total Post Discharge Savings			
Using Market Area Trends	131,596	175,040	258,804
Using National Trends	173,513	254,080	196,552

NOTE 1 Includes all heart bypass operations in DRG 106 or 107.

2 The demonstration began in May-June at the four original demonstration sites. The 1991 data include only cases covered under the demonstration

3 1993 values are based on discharges through September 30th

4 Post discharge savings are calculated as the difference between projected expenditures in lieu of the demonstration and actual expenditures during the 90 days after discharge

SOURCE 1990-93 MedPAR and NCH files

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example, in 1992, post-discharge savings per case were $2,150 using Atlanta market trend factors compared to $947 per case using national trend updates. Post-bypass savings estimates are also smaller for University Hospital-Boston using the national estimates, although the difference is not as great as for St. Joseph's. Both sets of estimates for OSU Hospital and St. Joseph Mercy Hospital, Ann Arbor, are very similar, as the market spending updates are similar to the national updates in these areas.

Clearly, total program estimates are significantly lower using national trend update factors, almost all of which results from the lower savings estimates in the Atlanta demonstration site. For example, in 1991 the total post-discharge savings across the four demonstration sites is $409,937 using the national updates and $1 million using the market area updates. The difference in the savings estimates for St. Joseph's Hospital in Atlanta under the two sets of updates is roughly $450,000 in 1991, $900,000 in 1992, and over $1 million through part of 1993.

The large differences in estimated savings per case across the demonstration sites were the result of large differences in post-discharge expenditure growth among the four sets of competitors. For example, post-discharge spending for competitors of St. Joseph's Hospital in Atlanta grew 50 percent between 1990 and 1991, while post-discharge spending for OSU Hospital's competitors grew by only 7 percent (not shown).

Given the degree of randomness in the data, our estimates of total savings rely on the post discharge savings based on national trends that provide lower, more conservative estimates.

5.3.3 Savings From Shifts in Market Shares

The third measure of savings presented includes savings resulting from shifts in market shares from competitor to demonstration hospitals. Table 5-5 presents program savings resulting from market share shifts. Since total savings depends on both the market share shift and the shift in DRG proportions within hospital, there is no intuitive method of aggregating the per case savings by DRG. Instead, savings are presented by DRG and then totalled for each site.

St. Joseph's Hospital in Atlanta experienced a market share increase for DRG 106 for all three years relative to the 1990 market share, and increases in the market share for DRG 107 in 1992 and 1993. These increases, coupled with a demonstration payment $5,000-$8,000 less than the payment received by competitor hospitals, led to additional savings of $7,002 in 1991, $91,406 in 1992, and $173,610 in 1993.

St. Joseph Mercy, Ann Arbor, also increased its market share in both DRGs from the 1990 baseline, particularly in 1993. As a result, additional total savings accrue to the program

TABLE 5-5

SAVINGS FROM SHIFTS IN MARKET SHARES AT THE FOUR ORIGINAL DEMONSTRATION HOSPITALS

	Jun-Dec 1991	Jan-Dec 1992	Jan-Sept 1993
FOUR ORIGINAL DEMONSTRATION SITES			
Total Savings from Market Share Shifts	**$19,418**	**$106,021**	**$259,397**
St. Joseph's - Atlanta			
DRG 106			
Payment to Competitors	31,195	33,401	34,755
Demonstration Payment	25,401	25,440	26,486
Savings per Case Shifted	5,794	7,961	8,269
Change from 1990 Market Share	0.034	0.028	0.021
Estimated Number of Cases Shifted	4.32	5.80	2.92
Savings from Market share shift	25,018	46,142	24,137
DRG 107			
Payment to Competitors	21,441	23,734	22,286
Demonstration Payment	18,457	20,877	18,983
Savings per Case Shifted	5,310	5,821	5,166
Change from 1990 Market Share	-0.013	0.018	0.074
Estimated Number of Cases Shifted	-3.39	7.78	28.93
Savings from Market share shift	-18,017	45,264	149,473
Total Savings from Market share shift	**$7,002**	**$91,406**	**$173,610**
University Hospital - Boston			
DRG 106			
Payment to Competitors	37,540	42,418	46,513
Demonstration Payment	34,305	34,309	35,652
Savings per Case Shifted	3,235	8,109	10,861
Change from 1990 Market Share	0.001	-0.033	-0.022
Estimated Number of Cases Shifted	0.06	-2.41	-1.36
Savings from Market share shift	188	-19,535	-14,814
DRG 107			
Payment to Competitors	31,640	34,310	33,773
Demonstration Payment	32,924	33,823	29,894
Savings per Case Shifted	-1,284	487	3,879
Change from 1990 Market Share	-0.017	-0.025	-0.015
Estimated Number of Cases Shifted	-1.11	-3.10	-1.55
Savings from Market share shift	1,419	-1,510	-5,993
Total Savings from Market share shift	**$1,606**	**($21,044)**	**($20,807)**

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TABLE 5-5 (continued)

SAVINGS FROM SHIFTS IN MARKET SHARES AT THE FOUR ORIGINAL DEMONSTRATION HOSPITALS

	Jun-Dec 1991	Jan-Dec 1992	Jan-Sept 1993
Ohio State University Hospital			
DRG 106			
Payment to Competitors	34,253	35,256	36,438
Demonstration Payment	26,356	26,356	26,356
Savings per Case Shifted	7,897	8,900	10,082
Change from 1990 Market Share	0.005	0.001	0.012
Estimated Number of Cases Shifted	0.24	0.07	0.82
Savings from Market share shift	1,856	650	8,227
DRG 107			
Payment to Competitors	33,185	33,354	30,988
Demonstration Payment	20,613	20,613	20,613
Savings per Case Shifted	12,572	12,741	10,375
Change from 1990 Market Share	-0.015	-0.014	-0.008
Estimated Number of Cases Shifted	-0.50	-0.76	-0.34
Savings from Market share shift	-6,223	-9,632	-3,486
Total Savings from Market share shift	**($4,367)**	**($8,982)**	**$4,741**
St. Joseph Mercy - Ann Arbor			
DRG 106			
Payment to Competitors	37,385	37,848	39,370
Demonstration Payment	31,279	31,615	34,372
Savings per Case Shifted	6,106	6,233	4,998
Change from 1990 Market Share	0.013	0.008	0.070
Estimated Number of Cases Shifted	1.14	1.18	13.72
Savings from Market share shift	6,985	7,330	68,573
DRG 107			
Payment to Competitors	33,412	33,137	31,817
Demonstration Payment	24,771	25,700	23,893
Savings per Case Shifted	8,641	7,437	7,924
Change from 1990 Market Share	0.012	0.029	0.035
Estimated Number of Cases Shifted	0.95	5.02	4.20
Savings from Market share shift	8,192	37,311	33,281
Total Savings from Market share shift	**$15,177**	**$44,641**	**$101,853**

NOTE:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites. The 1991 data include only cases covered under the demonstration.
3. 1993 values are based on discharges through September 30th.
4. Savings estimates do not include beneficiary savings.

SOURCE: 1990-93 MedPAR and NCH files.

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from this shift, ranging from $15,084 in 1991 to $101,292 in 1993.

Ohio State University experienced overall decreases in market share during 1991 and 1992 as the result of a small increases in market share for DRG 106 and larger decreases in market share for DRG 107. Consequently, the program experienced a small loss each year (-$4,367 and -$8,982) as the result of patient shifts to higher cost hospitals. In 1993, OSU increased its market share relative to the 1990 share, and the program experienced a savings of $4,741.

University Hospital in Boston experienced overall decreases in its market share in all three years relative to 1990. This produced program losses of $21,044 and $20,807 in 1992 and 1993 as patients were shifted to more expensive non-demonstration hospitals. In 1990, the decrease in market share led to a savings of $1,419 in DRG 107, as University Hospital was slightly more expensive than the average of its competitors. This perverse effect was unexpected, and it is not clear that savings as a result of shifts from the demonstration hospital to lower cost competitors should be considered as savings to the program. Fortunately, this effect is only found once, and the savings that result from it are quite small.

5.4 Summary of Cost Savings

Table 5-6 presents cumulative Medicare program savings from the inpatient stay, post-discharge savings, and savings resulting from shifts in market shares. Total savings at the four original demonstration hospitals, from the inception of the demonstration through September, 1993, total $15.3 million. This corresponds to a 14 percent discount on the projected expenditures of $110.8 million in lieu of the demonstration (not shown). The bulk of the savings, 90 percent, arises from the negotiated inpatient discounts, eight percent results from lower outlays in the 90 days after discharge, and two percent results from increases in market shares for the demonstration sites.

Total savings for the seven months of 1991 during which the demonstration was in operation totalled $4.0 million, and total savings for 1992 totalled $6.8 million. Savings for January through September, 1993, totalled $4.5 million, corresponding to an annual estimate of $6.0 million. Inpatient savings ranged from 85 percent of total savings in 1993 to 93 percent of total savings in 1992. Post-discharge savings constituted 6-11 percent of the total in each year, an unexpected result. The only component to grow as a proportion of total spending across the three years is the savings attributable to market share shifts, which is encouraging. This accounted for less than one percent of total savings in 1991, two percent in 1992, and six percent in 1993.

St. Joseph's Hospital in Atlanta had the largest cumulative savings across the three years. In fact, it had the largest cumulative savings for each of the three components, inpatient,

TABLE 5-6

TOTAL MEDICARE PROGRAM SAVINGS FOR FOUR ORIGINAL DEMONSTRATION HOSPITALS, 1991-93

	Jun-Dec 1991	Jan-Dec 1992	Jan-Sept 1993	Total
Four Demonstration Sites				
Inpatient Savings	$3,556,472	$6,317,988	$3,844,225	$13,718,685
Post Discharge Savings	409,905	387,449	407,911	1,205,265
Market Share Shift Savings	19,418	106,021	259,397	384,836
Total Savings	3,985,795	6,811,458	4,511,533	15,308,786
St. Joseph's - Atlanta				
Inpatient Savings	910,008	2,206,596	1,054,823	4,171,427
Post Discharge Savings	362,701	259,168	435,790	1,057,659
Market Share Shift Savings	7,002	91,406	173,610	272,018
Total Savings	1,279,711	2,557,170	1,664,223	5,501,104
University Hospital - Boston				
Inpatient Savings	1,154,232	1,599,510	901,890	3,655,632
Post Discharge Savings	9,967	-113,243	-76,523	-179,799
Market Share Shift Savings	1,606	-21,044	-20,807	-40,245
Total Savings	1,165,805	1,465,223	804,560	3,435,588
Ohio State University Hospital				
Inpatient Savings	814,880	1,372,362	1,046,320	3,233,562
Post Discharge Savings	-136,279	-12,674	-147,917	-296,870
Market Share Shift Savings	-4,367	-8,982	4,741	-8,608
Total Savings	674,234	1,350,706	903,144	2,928,084
St. Joseph Mercy - Ann Arbor				
Inpatient Savings	677,352	1,139,520	841,192	2,658,064
Post Discharge Savings	173,516	254,198	196,561	624,275
Market Share Shift Savings	15,177	44,641	101,853	161,671
Total Savings	866,045	1,438,359	1,139,606	3,444,010

NOTES:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites. The 1991 data include only cases covered under the demonstration.
3. 1993 values are based on discharges through September 30....
4. Savings estimates do not include beneficiary savings.

SOURCE: Savings estimates in Tables 5-2 through 5-5.

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post-discharge, and market share. The large inpatient savings and savings from growth in market share were not surprising, given St. Joseph's Hospital in Atlanta high volume of cases and increase in market share shown in Chapter 4. The level of post-discharge savings is surprising, given that shifts in post-discharge care were expected to create a loss to the program.

St. Joseph Mercy of Ann Arbor is similar to St. Joseph's Hospital in Atlanta in its positive post-discharge savings and savings resulting from market share increases. These two were, in fact, the two hospitals found to have significant growth in market shares across 1990-93 (Chapter 4).

University Hospital in Boston and Ohio State University Hospital have similar patterns of savings. Cumulative inpatient savings total over $3 million at both hospitals, and both show the expected cumulative loss in the post-discharge period from shifts to other facilities or to outpatient locations that can be billed separately outside the demonstration. Both had cumulative losses from decreases in market shares, although these were very small, and should not be assumed to be caused by participation in the demonstration.

In summary, the bulk of program savings at all four hospitals is comprised of the inpatient savings. Estimates of post-discharge savings and savings arising from market share shifts may reflect some random variation, given the difficulties inherent in the quasi-experimental design. However, given that these components comprise only eleven percent of the total savings estimates, the totals should be relatively insensitive to these problems.

Beneficiary savings are summarized in Table 5-7. Ninety-five percent of the $2.3 million in estimated savings results from the lower negotiated payment for the bypass hospitalization. Savings to beneficiaries from reductions in post-discharge utilization are quite small. This is not surprising since patients have already paid the Part A deductible, and would only accrue savings from reductions in Part B expenditures. The reduced inpatient demonstration liability also generates small savings as market shares increase for the demonstration sites.

TABLE 5-7

TOTAL MEDICARE BENEFICIARY SAVINGS FOR FOUR ORIGINAL DEMONSTRATION HOSPITALS, 1991-93

	Jun-Dec 1991	Jan-Dec 1992	Jan-Sept 1993	Total
Four Demonstration Sites				
Inpatient Savings	$512,737	$905,949	$817,433	$2,236,119
Post Discharge Savings	6,041	42,384	14,714	63,139
Market Share Shift Savings	4,216	15,802	43,366	63,384
Total Savings	522,994	964,135	875,513	2,362,642

NOTE:

1. Includes all heart bypass operations in DRG 106 or DRG 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites. The 1991 data include only cases covered under the demonstration.
3. 1993 savings are based on discharges through September 30th.

SOURCE: 1991-93 MedPAR and NCH files.

6.0 IMPACT OF BUNDLED PAYMENTS ON HOSPITAL COSTS

6.1 Introduction

By negotiating fixed discounts on average payments for DRG's 106 and 107, the Medicare program and its beneficiaries are assured of savings unless outpatient expenses associated with demonstration bypass patients rise faster than expected. Lower average payments, on the other hand, mean lower, or even negative, margins for the participating hospitals. Unless participants can reduce their costs of treating bypass patients, they may incur losses that may be unsustainable in the long run.

Participants can reduce the costs of treating bypass patients in several ways. First, they can change the patterns of inpatient care, such as shortening ICU stays, that reduce the need for variable hospital resources and supplies, including ICU nursing time and drugs. Second, if they are successful in increasing volumes, they can spread fixed costs across more cases and reduce average fixed costs per bypass patient. Third, by discharging earlier, they could shift more of the post-operative treatment to an outpatient setting, reducing the costs they personally incur by raising the costs to other providers, e.g., home health agencies, referring family physicians. The third possibility has already been addressed in the previous chapter. In the current chapter, attention is focused on the costs incurred by participants.

Whether any of the demonstration hospitals achieved cost savings is immaterial to the government in the sense that HCFA pays no more or less if the hospitals' own costs rise or fall. Yet, the government is very interested in whether participants achieved meaningful cost savings as part of the demonstration. If they did conserve resources, not only will they be more likely to continue under negotiated global rates, but other hospitals will have a stronger interest in global budgeting as well. The key question is:

> Will hospital costs fall when physician incentives to reduce spending are aligned with hospital incentives under DRG prospective payment?

Many physicians might argue that their inpatient practice patterns are unaffected by financial incentives: they give each patient what they need--especially very ill coronary artery disease patients requiring bypass surgery. Others, however, might argue that more cost-effective practice patterns can be implemented even for bypass surgery so long as physicians are willing to cooperate with hospital administration.

The economic literature (Pauly and Redisch, 1973; Pauly, 1980; Harris, 1977) supports the hypothesis that physicians tend to treat the hospital as their workshop. To them, the

inputs to patient care are practically free, including nurse time, radiological supplies, drugs, ICU telemetry, scanners, echocardiography, EKGs, and cardiac catheter devices. Surgeons and cardiologists pay nothing for this equipment and support in the inpatient setting; these costs are external to their own practices. Once physicians are under a single global rate, however, all of these costs are internalized. (How hospitals and physicians divide the global payment is relevant to how much of the hospital cost burden or savings physicians bear. See Chapter 13 on the split of the global payment under the demonstration.) Realizing that more cost-effective practice patterns could save the hospital money may encourage surgeons, in particular, to conserve on scarce resources. They might do so either out of a concern for the financial solvency of the hospital under the demonstration or in response to incentives to share in any cost savings by receiving a larger share of the global payment.

In evaluating the cost impacts of the demonstration, it is important to distinguish cost savings that might have accrued to greater volumes from those realized by more cost-effective practice patterns and/or better hospital management. Volume gains affect costs by lowering average fixed costs on all cases. Overall average costs per bypass patient could be lower, in this case, without any improvements in practice patterns or hospital management. Evaluating changes in average fixed (or indirect) costs should speak to the volume effects. Changes in practice patterns and hospital management, by contrast, should affect variable costs for the most part. Unfortunately, not all of the hospital micro-cost systems are equally detailed in distinguishing fixed from variable costs.

Key evaluation questions addressed in this chapter include:

- Did the costs of demonstration hospitals rise more slowly under fixed global payments than they would have under DRG prospective payment?
- Did the average total and variable margins on bypass patients rise or fall under the demonstration?
- What proportion of the costs of bypass surgery do hospitals consider fixed vs. variable? Did average fixed or variable costs per case change more?
- What is the level of costs by department for bypass patients? Did the costs of some departments rise or fall faster than others? If so, might this be indicative of changes in practice patterns or management efficiencies?

To answer these questions, Section 6.2, first, provides a brief summary of the micro-cost systems in the four participating hospitals. The next four sections present trends in hospital costs and margins by hospital. Section 6.7 then compares the key findings across institutions.

6.2 Data Sources and Methods

As a first step in analyzing trends in costs, each participating hospital submitted detailed cost information on every Medicare patient undergoing bypass surgery beginning in 1990, before the demonstration began, through 1993. (Cost data were not collected in the last six months of the demonstration in order to complete the evaluation within the five-year time/frame.) The data pertained only to the facility and did not include any physician inputs or charges unless they were paid for directly by the hospital.

6.2.1 Micro-Cost Systems

Only Ohio State University Hospital among the four institutions continued to use the traditional method of cost-to-charge ratios by department to determine patient costs. This system was used by all hospitals in the United States during the era of cost reimbursement. It involves distinguishing between overhead support, nursing, and ancillary services and then stepping down support costs into the nursing and ancillary departments. Next, patient days in routine and ICU nursing are divided into direct department plus stepdown costs to produce a per diem cost for all patients. Billing information on lengths of stay are then multiplied by these two average daily cost figures to produce estimates of total nursing costs for each bypass patient. Overhead costs are also stepped down into ancillary departments (e.g., operating room, laboratory) and an overall department cost-to-charge ratio calculated. Again, billing information is then used to determine each patient's "share" of department costs by multiplying charges by the cost-to-charge ratio.

Once Medicare prospective payment was introduced in late 1983, hospitals began replacing this old method of cost finding with more detailed, accurate methods. The principal problem with the old system arose from the use of very aggregate department-wide per diems and cost-to-charge ratios to isolate costs for individual patients. Two patients with equal radiology charges, for example, may generate different costs because their mix of procedures may be different. Ten chest x-rays may result in the same total charges as a single magnetic resonance scan, but may require more or less labor and supplies.

Both St. Joseph's Hospital in Atlanta and Boston University Hospital had implemented state-of-the-art micro-costing systems before the demonstration began. St. Joseph's Mercy Hospital in Ann Arbor converted to a very similar system late in the demonstration. In the process, the staff recalibrated their 1991-93 costs using the new system. Costing is done in these systems from the bottom up. First, department heads identify the procedures and services that comprise 80% of department charges. Then, applying management engineering

techniques, they identify the labor, supplies, and equipment inputs associated with each procedure. The average technician time required to perform an echocardiographic exam is determined, for instance, along with the feet of film, other supplies, and machine time. Next, a unit cost is determined for each input in each department, e.g., a technician's hourly wage. When unit costs are multiplied by the number of units of a service or procedure, a patient's total cost for a given procedure is generated. Summing across all the different procedure costs gives total costs incurred on behalf of the patient for the department. Finally, summing across all departments gives an estimate of the patient's total cost. Overhead costs are allocated to procedures on a fixed/variable basis. Because of the vast number of procedures performed every day in the inpatient setting, cost-to-charge ratios are used to identify costs for the residual 20% of services.

This approach to costing has many strengths. First, specific inputs are linked up with specific intermediate outputs at the department level. Calibrating the system gives department managers a much clearer understanding of the underlying costs associated with the procedures performed in their department. It also puts management on firm ground with clinical staff in explaining why certain procedures cost much more than others. A second advantage is the emphasis placed on categorizing inputs into fixed and variable, direct and indirect. Managers need to know what will happen to costs if volumes of patients or procedures rise. To do this, inputs must be classified as fixed and variable. This is where the art (and arbitrariness) of micro-costing comes in. As will be seen, hospitals using very similar micro-costing systems produce very different estimates of fixed and variable costs. As bypass patients are likely very similar in their procedure requirements when averaged over all admissions during a year, it is clear that large differences in fixed/variable proportions are the result of the costing system and not patient mix.

The micro-cost analysis naturally only considers hospital Part A payments and costs. This is because no Part B cost system exists for physician practices. It should also be emphasized that the estimated Part A component of the demonstration payment may not be what the hospital actually retained if physicians negotiated a larger share of the global payment. The purpose of estimating hospital-only margins, however, is to predict how much profit or loss the hospital could enjoy under the original Part A and B components before any transfers to physicians.

6.2.2 Financial Variables

By classifying costs into fixed and variable, financial managers are able to calculate two variants of patient margins, or profits. Net income is simply the difference between net

revenue and estimated patient costs and is sometimes referred to as average profit margin. In the demonstration, net revenue is the amount being paid under the negotiated rates amounting to two fixed amounts for all Medicare patients in DRG 106 or 107, respectively. For purposes of the analysis, the estimated Part B physician portion of the global rate is excluded as is any patient copay so as not to overstate the revenues available to the hospital to cover its own institutional costs.

What the hospital actually pays physicians generally is different from the estimates used by HCFA to determine the beneficiary copay and the trust fund split (see Chapter 13). It is also true that it would be entitled to a portion of the patient liability representing the Part A deductible. Because the Part A deductible is a small portion of the coinsurance, on average, only what HCFA estimated its Part A liability to be was used in defining the hospital's net revenue.

The second measure of financial performance is the variable margin, calculated as the difference between net revenue and total variable costs. Positive variable margins imply that bypass patients are more than covering the extra that are incurred during their admission. Fixed costs are excluded. Variable margins are always greater than net income or average margins because of positive fixed costs. In the short run, financial managers should be willing to accept any patients that more than cover their own variable costs and help pay for some of the fixed costs. It is also possible for a hospital simultaneously to experience positive variable margins and negative average net income on bypass patients if they are not "covering their share" of allocated fixed costs.

Are demonstration patients "losers" from the hospital's perspective if net income is negative. The answer, most likely, is no. Some hospital administrators and physicians may think so, however. All hospitals offered discounts on their DRG rates and are taking losses in the sense that they could have received more revenue from HCFA, all other things constant if they had continued to receive prospective DRG payments. But things are not constant. Consider the financial implications of having fewer or no bypass patients during a given year. Large fixed costs would go uncovered, not to mention the staff that would have to be laid off and costly inventories that would be stockpiled and not used, tying up cash flow. Then there are the spillover effects of the demonstration to be considered as well. If participating in the demonstration generates other bypass or medical-surgical admissions, then the net income associated with demonstration patients is underestimated. Furthermore, if aligning physician and hospital incentives results in lower costs for non-Medicare bypass patients, then profitability on private patients is increased.

6.2.3 Data Sources

Data were submitted in different computerized files by each of the participants covering the 1990-93 period. Each hospital was asked to submit a set of baseline files on Medicare bypass patients prior to the start of the demonstration, followed by annual submissions of micro-cost data. One file contained background information on the patient, including age, sex, admission and discharge date, revenues, and the like. Another file usually summarized each patient's cost information at the department level in 6-9 variables, e.g., direct variable, direct nonsalary, indirect administration. Finally, in the three hospitals using detailed micro-cost systems, a patient-procedure-service file was provided. This file contained thousands of observations listing all of the individual drugs, lab tests, operating room supplies, etc., each patient received.

Often, these files were submitted in a different variable layout. Department codes changed, necessitating the use of inter-year crosswalks to align services with departments. Hospitals differed in their breakdown of departments; thus, it was not possible to present a uniform set of departmental data for comparison purposes--although all important cost centers are available. More detrimental to interhospital comparisons was the lack of uniform definitions of indirect vs. direct costs or variable vs. fixed costs. Some hospitals, for example, allocated most of central supplies to ancillary services while others kept it as a separate indirect overhead department. Some hospitals broke out the blood bank or rehabilitation cost centers from the lab and physical therapy, respectively, while others simply merged them. Even over time within the same hospital, systems changed. Blood bank may be reported for three years but not the last year.

Estimating the volume effects on costs proved impossible with the data provided. The key variable, average fixed costs, is influenced by more than just bypass volume. Average fixed costs per surgery in the operating room, for example, not only depends upon the growth in bypass surgery but other surgery as well. Not enough detail was available on non-demonstration hospital volumes to meaningfully isolate demonstration specific volume effects on costs.

Another problem with the cost data is the fact that they are always in current dollars. Costs rise over time because of rising wage rates, drug prices, more costly equipment, etc., not to mention changes in practice patterns. Hence, the results presented below make no adjustments for general inflation in the hospital sector. This is not a problem in determining the profitability of demonstration cases because net revenues have been updated using HCFA methods under the demonstration. However, cost trends alone will overstate the trend in real resources, procedures, and services used to treat bypass patients. Given that somewhat over

half the annual rise in hospital costs can be traced to input price inflation outside the industry's control (Cromwell and Butrica, 1994), the bias probably amounts to roughly 5% a year over the three years of the demonstration. That is, one would have expected the costs of bypass patients to rise nearly 16% due to higher input prices alone, ignoring the trend towards more intensive care (Mitchell, *et al.*, 1993; Adamache, *et al.*, 1994).

No independent assessment has been made of the accuracy of the cost figures. Direct variable costs attributed to a patient can be considered fairly accurate as they relate to specific services received. Indirect fixed costs are more problematic because they can be allocated to patients in different ways. For the three hospitals using state-of-the-art costing systems, at least the total costs should be within the acceptable range as well as for many of the key departments. It is in each hospital's best interest to make the cost allocation as accurate as possible. None of the micro-cost systems are used to maximize reimbursement; only to inform managers of real costs by type of patient. Significant costing problems were encountered at the department level for Ohio State University Hospital.

6.3 Cost and Margin Trends in St. Joseph's Hospital, Atlanta

6.3.1 Overall Costs and Margins

Tables 6-1 and 6-2 summarize trends in cost, charge, revenue and profit trends for St. Joseph's Hospital in Atlanta beginning a year before the demonstration started and extending through December, 1993. During the baseline 1990 period, the average total cost of DRG 106, bypass with catheterization, was $22,118, excluding any physician costs. Three years later, costs averaged $20,208, a reduction $1,910, or 8.6%. Variable costs, which were estimated to be over twice as much as fixed costs in the baseline period, fell 19.2%. Fixed costs rose 14%.

Average total costs per case fell even more in DRG 107: $2,296, or 12.9%. Variable costs fell by nearly 25% while fixed costs per case rose about the same, percentage-wise, as in DRG 106.

If one assumes, conservatively, that input price inflation averaged about 16% over the same period, then variable costs in real terms may have fallen as much as 25% in DRG 106 and 41% in DRG 107. These remarkable gains were offset to some extent by the increase in average fixed costs, especially in 1991 due a major facility expansion.

The three largest cost components, as expected, were direct variable salaries, including OR, ICU, and routine nursing, amounting to $5,203 in DRG 106 in 1993; direct variable nonsalary costs, including drugs, central supplies, OR supplies, cath and other lab supplies, etc., averaged $6,136; while indirect fixed nonsalary costs were $3,975.

TABLE 6-1

DRG 106 AVERAGE COSTS, REVENUES, AND MARGINS PER DEMONSTRATION PATIENT, 1990-1993: ST. JOSEPH'S HOSPITAL, ATLANTA

Category	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	90	140	221	246	-
Total Charges	$34,867	$37,794	$40,856	$37,539	+7.7 %
Variable Cost	14,951	13,261	13,349	12,039	-19.2
Fixed Cost	7,167	8,950	9,239	8,169	+14.0
Total Direct Cost	**16,155**	**16,236**	**16,097**	**14,007**	**-13.3**
-Variable Salary	6,366	5,797	5,799	5,203	-18.3
-Variable Non-Salary	7,170	6,514	6,786	6,136	-14.4
-Fixed Salary	795	1,746	1,692	1,117	+40.5
-Fixed Non-Salary	1,029	1,049	1,206	1,012	-1.7
-Fixed Capital	796	1,130	614	540	-32.2
Total Indirect Cost	**5,962**	**5,975**	**6,491**	**6,201**	**+4.0**
-Variable Salary	464	656	543	474	+2.2
-Variable Non-Salary	951	294	221	226	-75.1
-Fixed Salary	738	1,797	1,470	1,336	+81.0
-Fixed Non-Salary	2,054	2,704	4,038	3,975	+93.5
-Fixed Capital	1,756	524	219	190	-89.2
Total Cost	**22,118**	**22,211**	**22,588**	**20,208**	**-8.6**
Net Revenue	20,636	21,432	21,465	22,334	+8.2
Net Income	-1,482	-779	-1,123	2,126	-
Variable Margin	5,685	8,171	8,116	10,295	+81.1

NOTES:

1. Variable Margin = Net Revenue - Variable Cost;
2. Net Income = Net Revenue - Total Cost.
3. Net revenue for 1991 slightly different than $20,362 reported by hospital.
4. Net revenues for 1991-93 = Part A amount estimated by HCFA/ORD.

SOURCE: St. Joseph Hospital Micro-Cost Accounting System.

TABLE 6-2

DRG 107 AVERAGE COSTS, REVENUES, AND MARGINS PER DEMONSTRATION PATIENT, 1990-1993: ST. JOSEPH HOSPITAL, ATLANTA

Category	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	216	261	424	419	-
Total Charges	$28,774	$29,714	$30,540	$28,283	-1.7 %
Variable Cost	12,255	10,347	10,101	9,232	-24.7
Fixed Cost	5,500	6,974	6,842	6,228	+13.2
Total Direct Cost	**13,086**	**12,650**	**12,098**	**10,702**	-18.2
-Variable Salary	5,205	4,783	4,484	4,139	-20.5
-Variable Non-Salary	5,293	4,795	5,034	4,545	-14.3
-Fixed Salary	670	1,383	1,290	869	+29.7
-Fixed Non-Salary	728	785	878	772	-6.0
-Fixed Capital	560	904	412	377	-32.7
Total Indirect Cost	**4,670**	**4,671**	**4,845**	**4,758**	+1.9
-Variable Salary	359	525	410	368	2.5
-Variable Non-Salary	768	244	173	180	-76.6
-Fixed Salary	359	1,446	1,105	1,039	+189.4
-Fixed Non-Salary	1,582	2,034	2,993	3,024	+91.2
-Fixed Capital	1,373	423	165	147	-89.3
Total Cost	**17,756**	**17,321**	**16,943**	**15,460**	**-12.9**
Net Revenue	16,865	18,457	20,878	18,973	+12.5
Net Income	-891	1,136	3,935	3,513	-
Variable Margin	4,610	8,110	10,777	9,741	+111.1

NOTES

1. Variable Margin = Net Revenue - Variable Cost.
2. Net Income = Net Revenue - Total Cost

SOURCE: St. Joseph Hospital Micro-Cost Accounting System

Based on the hospital's costing definitions, two-thirds of bypass costs were considered variable. This is a far higher percentage than in other demonstration hospitals. This implies that 10% growth in bypass volume would only reduce average costs by 3.3% as it would only reduce average fixed costs.

At the same time average costs were falling in St. Joseph's Hospital, total charges were rising but only by 7.7% over four years. Price increases were offset almost completely by fewer services per admission.

Demonstration hospitals, of course, are not paid their charges, and net revenue is the relevant variable for cash flow. For 1990, the year before the demonstration, St. Joseph's Hospital received $20,636 in Medicare prospective payments for DRG 106 bypass patients and $16,865 for DRG 107 patients. Net incomes, or profits per patient, were -$1,482 for DRG 106 and -$891 for DRG 107. Over the next three years of the demonstration, average net revenues rose 8.2% for DRG 106 and 12.5% for DRG 107. Revenues for 1991-93 were based on the negotiated global rates, updated for the Medicare market basket, local wage changes, and any changes in the relative value weights for the two DRGs. Thus, for DRG 106, the hospital turned a loss, on average, into a $2,126 gain by 1993, due to absolute cost savings. For DRG 107, the turnaround was even more dramatic. By 1993, the hospital was enjoying a profit of $3,513 per case due to the large absolute decline in costs.

The impact of the cost savings is far greater when considering variable margins. For DRG 106, these margins rose from roughly $5,700 to over $10,000 for DRG 106, and from roughly $4,600 to over $9,700 on DRG 107. That is, over the short run, given that one-third of hospital costs were fixed, additional Medicare demonstration patients were contributing approximately $10,000 each to short-run profits. Not only did St. Joseph's Hospital enjoy significant volume growth and increased market share in Atlanta, it also significantly reduced its costs to become a big financial winner under the demonstration. What the hospital did with the extra monies is described in Chapter 13 in the distribution of profits to physicians.

6.3.2 Departmental Costs

Tables 6-3 and 6-4 decompose trends in direct costs alone by major cost center. Indirect costs are ignored as they are assumed to be little affected by changes in the management of bypass patients. In 1990, the hospital incurred $16,155 in average direct costs per DRG 106 patient, of which the operating room and recovery was the largest contributor (22%) followed by ICU nursing (18%). These two cost centers remained the most expensive through 1993, but their relative importance diverged considerably. Operating room costs actually rose nearly

TABLE 6-3

DRG 106 AVERAGE DIRECT COSTS PER MEDICARE PATIENT BY DEPARTMENT, 1990-1993:
ST JOSEPH'S HOSPITAL, ATLANTA

Cost Center	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	90	140	221	246	-
Nursing ICU	2,885	2,923	2,656	2,177	-24.5 %
Nursing General	1,998	1,981	1,607	1,351	-32.4 **
Pharmacy	1,551	1,334	1,306	1,059	-31.7 **
OR & Recovery	3,559	3,910	4,338	4,252	+19.5 **
Anesthesia	236	220	271	260	+10.2 **
Radiology	358	288	352	299	-16.5
Laboratory	1,180	617	617	432	-63.3 **
Physical Therapy	64	69	87	70	+9.4
Respiratory Therapy	949	1,046	1,070	852	-10.2
Blood Bank	835	727	736	678	-18.8
EKG & EEG	345	430	355	293	-15.1 *
Catheter Lab	1,443	1,752	1,584	1,477	+2.4
Rehabilitation	105	125	119	113	+7.6
Central Supply	376	451	570	415	+10.4
IV Therapy	112	99	104	66	-41.4 **
Other	159	246	311	201	+26.4 **
Total	16,155	16,218	16,082	13,996	-13.4

NOTES: Direct costs are for services directly assigned patients in the listed departments.
Exclude indirect overhead costs centers.

** = Significant at 5%

* = Significant at 10%

SOURCE: Developed from Micro-cost datafiles, St. Joseph's Hospital, Atlanta.

TABLE 6-4

DRG 107 AVERAGE DIRECT COSTS PER MEDICARE PATIENT BY DEPARTMENT, 1990-1993: ST JOSEPH'S HOSPITAL, ATLANTA

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	216	261	424	419	-	
Nursing ICU	2,265	2,293	1,920	1,569	-30.7 %	**
Nursing General	1,611	1,682	1,313	1,191	-26.1	**
Pharmacy	1,375	976	987	750	-45.5	**
OR & Recovery	3,715	3,765	4,193	4,186	+12.7	**
Anesthesia	230	213	263	253	+10.0	**
Radiology	327	242	270	242	-26.0	**
Laboratory	1,023	555	519	370	-63.8	**
Physical Therapy	67	50	78	62	-7.5	
Respiratory Therapy	893	1,011	862	740	-17.1	
Blood Bank	679	601	639	459	-32.4	**
EKG & EEG	281	377	267	203	-28.8	**
Catheter Lab	44	30	41	38	-13.6	
Rehabilitation	107	131	114	108	+1.0	
Central Supply	297	354	383	311	+4.7	
IV Therapy	97	83	84	56	-42.2	**
Other	75	242	112	132	+76.0	
Total	13,086	12,606	12,047	10,670	-18.5	**

NOTES: Direct costs are for services directly assigned patients in the listed departments. Exclude indirect overhead costs centers.

** = Significant at 5%

* = Significant at 10%

SOURCE: Developed from Micro-cost datafiles, St. Joseph's Hospital, Atlanta.

20% on average while ICU nursing costs fell nearly 25%. Thus, by 1993, operating room costs were 30% of average direct costs while ICU nursing costs had fallen to 16%.

The 13.4% decline in average direct costs over four years was primarily due to declines in ICU nursing, general floor nursing, the pharmacy, and the laboratory. Several other departments also saw their direct costs fall per bypass patient.

Similar results obtain for DRG 107. Over the four years, the share of direct costs incurred in the operating room increased along with the department's costs while overall costs fell almost 19%. Again, the source of declining costs are found in the same four cost centers.

The largest contributing factor to lower costs in both DRGs is shorter stays that conserve on scarce nursing inputs and other nursing-related services, e.g., bedside telemetry, central supplies. Notable savings have also been realized in the pharmacy. In Chapters 10 and 11, the patient and organizational changes that were implemented to realize such large savings are discussed.

6.4 Cost and Margin Trends in Boston University Hospital

6.4.1 Overall Costs and Margins

Tables 6-5 and 6-6 present trends in costs, charges, revenues, and margins, or profits, for Boston University Hospital. During the baseline period, 1990, the average total cost of DRG 106, excluding physician costs, was $33,111. Three years later, DRG 106 costs averaged $30,886, a 6.7% reduction representing a savings of $2,225. Average total costs for DRG 107 fell by 4% as well. Any reductions in absolute costs is a remarkable achievement over a period with input prices rising several percent a year alone, without taking into account greater intensity of services each year.

Boston University Hospital provided a fixed-variable cost breakdown only for direct costs, assuming all indirect costs are fixed in the short run. On this basis, the hospital assumed that only about one-third of average total bypass costs in DRG 106 were variable. (The proportion was closer to 40% in DRG 107.) Hence, increased bypass volumes would have pronounced effects on average costs by spreading fixed costs over more cases.

By 1993, the direct-indirect cost split for DRG 106 was almost exactly 50-50. Interestingly, the 6.7% reduction in costs was achieved on the fixed portion. Direct patient costs rose nearly 5%; still a modest change over three years. If the cost reductions were due to the demonstration, one would have predicted they would have come in the direct cost centers that are most affected by improvements in patient care management. There are several explanations for this result. First, indirect costs are not all fixed. Changes in capital depreciation allowances, overhead management staff, etc. can occur over several years.

TABLE 6-5

DRG 106 AVERAGE COSTS, REVENUES, AND MARGINS PER DEMONSTRATION PATIENT, 1990-1993: UNIVERSITY HOSPITAL, BOSTON

Category	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	109	60	75	82	
Total Charges	44,665	43,448	51,020	49,038	9.8 %
Total Direct Cost	14,898	13,456	14,746	15,633	4.9
-Variable Cost	12,699	11,067	12,612	12,722	0.2
-Fixed Cost	2,199	1,889	2,134	2,911	32.4
Total Indirect Cost	18,214	15,805	16,627	15,253	-16.3
Total Cost	**33,111**	**29,261**	**31,373**	**30,886**	**-6.7**
Net Revenue	34,517	30,301	30,804	31,976	-7.4
Net Income	1,406	1,540	-569	1,090	-22.5
Variable Margin	21,818	19,734	18,192	19,254	-11.8

NOTES:

1. Variable Margin = Net Revenue - Variable Cost;
2. Net Income = Net Revenue - Total Cost.
3. Net revenue for 1991-93 = Part A amount estimated by HCFA/ORD.

SOURCE: University Hospital Micro-Cost Accounting System.

TABLE 6-6

DRG 107 AVERAGE COSTS, REVENUES, AND MARGINS PER DEMONSTRATION PATIENT, 1990-1993: UNIVERSITY HOSPITAL, BOSTON

Category	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	103	65	125	141	
Total Charges	32,380	37,059	36,509	35,125	8.5 %
Total Direct Cost	9,758	10,781	10,410	10,576	8.4
-Variable Cost	8,202	9,224	8,925	8,516	3.8
-Fixed Cost	1,556	1,557	1,485	2,060	32.4
Total Indirect Cost	11,714	12,608	11,773	10,045	-14.3
Total Cost	21,471	23,389	22,182	20,621	-4.0
Net Revenue	31,406	29,938	30,737	27,206	-13.4
Net Income	9,935	6,549	8,555	6,685	-
Variable Margin	23,204	20,714	21,812	18,690	19.5

NOTES:

1. Variable Margin = Net Revenue - Variable Cost.
2. Net Income = Net Revenue - Total Cost.

SOURCE: University Hospital Micro-Cost Accounting System.

Second, if the growth in direct costs in bypass-oriented departments was slower than for other conditions and procedures, then fewer indirect costs may have been allocated to them. Third, there may have been a shift of some costs from indirect to direct over the period. Fourth, there may have been significant increases in hospital volume, either of bypasses or other conditions, that spread fixed costs over more cases. Only the second reason (and possibly the fourth) could be ascribed to demonstration effects. Thus, it is unlikely that the demonstration was responsible for the absolute decrease in DRG 106 and 107 costs. On the other hand, it may have been the principal reason why direct costs rose so slowly.

At the same time average total costs were falling, average charges for Medicare patients were rising between 8.5% (DRG 107) and 9.8% (DRG 106). Net revenues under the demonstration, however, moved in the opposite direction, falling 7.4% for DRG 106 and 13.4% for DRG 107. The net result of declining demonstration revenues and costs was a $316 dollar decline in net incomes for DRG 106 and a $3,250 decline for DRG 107. Hence, the hospital was not able to overcome the (estimated) Part A hospital discounts by lowering costs to break/even. It should be remembered, though, that the negative cost increases no doubt pertain to all bypass patients, not just Medicare. For other payers paying discounted charges, it is possible that profits have improved considerably.

Because Boston University Hospital considers so few costs to be variable, its variable, short-run margins on demonstration patients are extremely high. Even though these margins fell over the three years, they still exceeded $18-19,000 in 1993. Even on a direct cost basis, BU's margins would have been on the order of $16,000. Hence, the hospital should consider these patients quite profitable. Of course, the hospital could receive even more under the PPS program, but then it may not have achieved its cost reductions without the change in incentives.

6.4.2 Departmental Costs

Tables 6-7 and 6-8 decompose trends in direct patient costs by department. In 1990, the baseline year, the hospital incurred $14,717 on average on DRG 106 Medicare patients. This figure grew 6.2% over the next three years, but was not statistically different from the 1990 base. (This increase is slightly more than reported on Table 6-5 due to slightly fewer cases.) Several departments showed absolute cost savings over the period, although only two declines were statistically significant: (1) the laboratory fell 25.6%; and (2) the catheter lab fell 29.2%. The other notable reduction was in general nursing, where costs fell nearly $300, or 10.4%, but the difference was not quite statistically significant.

TABLE 6-7

DRG 106 AVERAGE DIRECT COSTS PER MEDICARE PATIENT BY DEPARTMENT, 1990-1993: BOSTON UNIVERSITY HOSPITAL, BOSTON

Cost Center	July 1990 to June 1991	July - Dec 1991	Jan - Dec 1992	Jan - Dec 1993	Percent Change 1990 - 93
Number of Patients	104	60	75	82	
Nursing ICU	3,388	3,272	3,352	3,417	+0.9 %
Nursing General	2,730	2,300	2,481	2,456	-10.4
Pharmacy	898	789	915	1,003	+11.0
OR and Recovery	2,229	2,005	1,961	2,342	+9.7
Anesthesia	585	404	436	525	-2.2
Radiology	535	379	527	514	-12.4
Laboratory	862	727	726	643	-25.6 **
Physical Therapy	310	251	307	287	-7.7
Respiratory Therapy	403	366	501	389	-14.0
Blood Bank	899	1,013	1,627	1,802	+102.2 **
EKG & EEG	69	70	67	65	-5.8
Catheter Lab	1,708	1,765	1,261	1,211	-29.2 **
Other	101	46	301	264	+161.3 **
Total	14,717	13,387	14,460	14,918	+6.2

NOTES: 1. Direct costs are for services directly assigned patients in the listed departments. Exclude indirect overhead costs centers

2. Totals to not equal departments due to smaller unallocated departments.

** = Significant at 5%

* = Significant at 10%

SOURCE: Developed from Micro-cost datafiles, Boston University hospitals.

TABLE 6-8

DRG 107 AVERAGE DIRECT COSTS PER MEDICARE PATIENT BY DEPARTMENT, 1990-1993: BOSTON UNIVERSITY HOSPITAL, BOSTON

IPDGROUP	July 1990 to June 1991	July - Dec 1991	Jan - Dec 1992	Jan - Dec 1993	Percent Change 1990 - 93
Number of Patients	91	65	125	141	
Nursing ICU	1,969	2,467	2,111	1,781	-9.5 %
Nursing General	2,053	2,108	1,734	1,833	-10.7
Pharmacy	679	785	643	703	+3.5
OR and Recovery	2,207	2,060	1,782	2,302	+4.3
Anesthesia	553	448	428	524	-6.1
Radiology	410	502	366	385	-6.1
Laboratory	587	654	487	397	-32.3 **
Physical Therapy	261	305	714	214	-18.0 **
Respiratory Therapy	292	494	420	288	-1.4
Blood Bank	555	1,004	1,262	1,316	+137.1 **
EKG & EEG	47	45	39	36	-23.4 **
Catheter Lab	26	21	24	32	+23.1
Other	94	85	126	115	+22.3
Total	9,738	10,978	10,137	9,925	+8.5

NOTES: Direct costs are for services directly assigned patients in the listed departments. Exclude indirect overhead costs centers.

** = Significant at 5%

* = Significant at 10%

SOURCE: Developed from Micro-cost datafiles, Boston University hospitals.

DRG 107 showed a similar cost increase (8.5%) that, again, was not statistically distinct from 1990. Nursing costs were down, in total, from roughly $4,000 in 1990 to $2,600 in 1993, although the difference in either department was not statistically significant. Statistically significant reductions occurred again in the laboratory as well as physical therapy. It is also worth noting that the combined costs in the operating room and recovery, including anesthesia, rose only $61 in three years in this DRG. Pharmacy costs were kept almost flat as well.

One large increase occurred in the blood bank, with average costs rising from $555 to $1,316 in DRG 107. A similar large increase in blood processing, products, and administration was also found in DRG 106. The reason for this increase in unknown.

6.5 Cost and Margin Trends in St. Joseph's Mercy Hospital, Ann Arbor

6.5.1 Overall Costs and Margins

Tables 6-9 and 6-10 present data on costs and margins for St. Joseph's Mercy Hospital in Ann Arbor. In 1990 before the demonstration began, average total costs for DRG 106 patients were $27,541. Four years later, costs had fallen to $21,106, a reduction of 23.4%. In DRG 107, the success of the hospital in reducing costs was much less, but still a 2% savings in average total direct costs was achieved. In DRG 106, average variable costs fell 36.7% while in DRG 107 they fell 19.3%. Average fixed costs moved in opposite directions in the two DRGs, falling nearly 7% in DRG 106 while rising 19% in DRG 107. Again, any reduction in average costs is a notable achievement when input prices were rising several percentage points annually, not to mention the secular trend towards greater intensity.

Based on hospital definitions, roughly 55% of DRG 106 and 107 costs were considered variable in 1990 compared to 45% four years later. This would imply that a 10% increase in bypass volume would translate into about a 5% reduction in average total cost given that roughly half of costs are variable and would rise with greater volume.

Not only did total costs fall for DRG 106 patients, but average charges fell as well (-14%). Charges rose slightly for DRG 107 (+7.8%). Hospital net revenues were unchanged over the 1990-92 period for DRG 106 before being updated by HCFA by approximately $2,400 in 1993. Average payments rose 7.9% in DRG 106 between the baseline year and the third year of the demonstration. Net revenues actually fell by a similar percentage for DRG 107; again all the change taking place in 1993 as the DRG was revalued by HCFA.

Hospital net incomes, or average margins, were positive for both DRGs in the pre- and post-demonstration periods. Average profits increased by over $8,000 in DRG 106 due to the 23% decline in costs and the 8% increase in net revenues. Net incomes fell by slightly over

TABLE 6-9

DRG 106 AVERAGE COSTS, REVENUES, AND PROFITS PER MEDICARE DEMONSTRATION PATIENT, 1990-1993: ST. JOSEPH MERCY HOSPITAL, ANN ARBOR

Category	July-Dec 1990	Jan-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	69	153	167	124	-
Total Charges	$50,942	$43,640	$43,210	$43,831	-14.0 %
Variable Cost	15,225	13,098	12,798	9,644	-36.7
Fixed Cost	12,316	11,112	11,179	11,463	-6.9
Total Direct Cost	**14,787**	**12,729**	**12,817**	**11,914**	**-19.4**
-Variable Salary	8,919	7,351	7,034 *	-	-21.1 [a]
-Supplies	4,687	4,287	4,272 *	-	-8.9 [a]
-Other Costs	814	749	763 *	-	-6.3 [a]
-Variable Costs	-	-	10,861	8,915	-
-Fixed Costs	367	342	1,956	2,999	+717.2
Total Indirect Cost	**12,755**	**11,581**	**11,161**	**9,191**	**-27.9**
-Administration	3,339	3,040	3,151 *	-	-5.6 [a]
-Benefits	1,609	1,421	1,457 *	-	-9.4 [a]
-Support	2,961	2,691	2,839 *	-	-4.1 [a]
-Building	1,541	1,342	1,389 *	-	-9.9 [a]
-Other Costs	3,304	3,089	3,208 *	-	-2.9 [a]
Total Cost	**27,541**	**24,309**	**23,977**	**21,106**	**-23.4**
Net Revenue	27,771	27,265	27,558	29,972	+7.9
Net Income	230	2,956	3,581	8,866	-
Variable Margin	12,546	14,167	14,760	20,328	+62.0

NOTES:

1. Variable Margin = Net Revenue - Variable Cost;
2. Net Income = Net Revenue - Total Cost.
3. Includes only Medicare patients.
4. Variable costs assumed to include direct variable salaries, supplies, and other costs plus one-half of indirect benefits. In 1993, indirect benefits assumed to equal $1,457.
5. 1990 Net Revenues include PPS passthrough amounts.

* Detailed cost categories available for patients only through first six months of 1992. Subtotals do not add to totals which are based on all 167 patients in 1992.

[a] Percent change based on available data for 1992 vs. 1990.

SOURCE: St. Joseph Mercy Hospital Micro-Cost Accounting System.

TABLE 6-10

DRG 107 AVERAGE COSTS, REVENUES, AND PROFITS PER MEDICARE DEMONSTRATION PATIENT, 1990-1993: ST. JOSEPH MERCY HOSPITAL, ANN ARBOR

Category	July-Dec 1990	Jan-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	66	134	185	79	-
Total Charges	$33,944	$32,532	$34,073	$36,590	+7.8 %
Variable Cost	9,996	9,591	10,665	8,063	-19.3
Fixed Cost	8,239	8,433	8,484	9,803	+19.0
Total Direct Cost	**9,692**	**9,296**	**10,029**	**9,917**	+2.3
-Variable Salary	5,922	5,367	5,698 *	-	-3.8 [a]
-Supplies	3,036	3,152	3,674 *	-	+21.0 [a]
-Other Costs	504	530	653 *	-	+29.6 [a]
-Variable Costs	-	-	-	7,423	-
-Fixed Costs	230	247	1,499	2,494	+988.3
Total Indirect Cost	**8,543**	**8,727**	**9,119**	**7,947**	**-7.0**
-Administration	2,163	2,236	2,728 *	-	+26.1 [a]
-Benefits	1,068	1,083	1,279 *	-	+19.8 [a]
-Support	2,061	2,123	2,505 *	-	+21.5 [a]
-Building	1,028	1,013	1,224 *	-	+19.1 [a]
-Other Costs	2,221	2,274	2,744 *	-	+23.5
Total Cost	**18,235**	**18,023**	**19,148**	**17,865**	**-2.0**
Net Revenue	22,370	21,544	22,352	20,733	-7.3
Net Income	4,135	3,521	3,204	2,868	-
Variable Margin	12,374	11,953	11,687	12,670	+2.4

NOTES:

1. Variable Margin = Net Revenue - Variable Cost.
2. Net Income = Net Revenue - Total Cost.
3. Includes only Medicare patients.
4. Variable costs assumed to include direct variable salaries, supplies, and other costs plus one-half of indirect benefits. In 1993, indirect benefits assumed to equal $1,457.

* Detailed cost categories available for patients only through first six months of 1992. Subtotals do not add to totals which are based on all 167 patients in 1992.

[a] Percent change based on available data for 1992 vs. 1990.

SOURCE: St. Joseph Mercy Hospital Micro-Cost Accounting System. CMC016.SAS

$1,000 for DRG 107, even though total costs fell 2%, due to the reduction in HCFA estimated payments for the hospital Part A portion of the global rate.

Variable margins on both DRGs remained in excess of $12,000 per case. In DRG 106, variable margins rose $8,000, peaking at over $20,000 per case in 1993. The hospital was more successful in controlling variable than fixed costs in DRG 107. As a result variable margins remained at a constant $12,000-plus between the baseline and the third demonstration year.

6.5.2 Departmental Costs

Tables 6-11 and 6-12 decompose trends in direct patient costs by department. Unlike the other three hospitals in the demonstration, St. Joseph's Mercy submitted data on all their bypass patients, not just Medicare. For consistency with earlier tables, only the Medicare cost data are reported here. The significant decline in direct costs in DRG 106 was the result of declining costs in many departments at St. Joseph's Mercy Hospital. Nursing costs fell 34-40% over three years, pharmacy costs fell 34%, radiology costs fell 25%, lab costs fell 20%, and respiratory therapy costs fell 29%. Even operating room costs, which rose considerably in other hospitals, fell 13%. Of the significant cost centers, only catheter lab costs showed an increase per case (= 19%), although even this growth was not statistically significant.

Direct costs, by contrast, actually rose 2.3% over the period in DRG 107. This was true even though nursing costs fell 12-18%. The only category to show a significant increase was "other costs". (A similar increase was found for DRG 106 as well.) This could be due to real increases in other, unlisted, departments, or possibly to a reassignment of some costs from a reported cost center to a miscellaneous category.

In general, these results confirm the case study findings of significant changes in patient care management in the hospital, particularly regarding lengths of stay in the ICU and on the routine floors. Reductions in pharmacy, operating room/anesthesia, and radiology and lab costs are also evident.

6.6 Cost and Margin Trends for Ohio State University Hospital

6.6.1 Overall Trends

Tables 6-13 and 6-14 present data on costs, revenues, and margins for Ohio State University Hospital for the 1990-93 period. The hospital only decomposes costs into direct and indirect. Over the three year period, average bypass costs rose 10.9% for DRG 106 and 24.2% for DRG 107. Both direct and indirect costs rose faster for DRG 107. Thus, unlike other demonstration hospitals, OSU Hospital was not able to reduce costs per case, although DRG

TABLE 6-11

DRG 106 AVERAGE DIRECT COSTS PER MEDICARE PATIENT BY DEPARTMENT, 1990-1993:
ST. JOSEPH MERCY HOSPITAL, ANN ARBOR

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	69	153	167	124		
Nursing ICU	4,358	3,408	3,085	2,869	-34.2 %	**
Nursing General	1,475	1,081	1,097	882	-40.2	**
Pharmacy	1,101	844	870	718	-34.8	**
OR & Recovery	3,190	3,181	3,098	2,771	-13.1	**
Radiology	384	298	317	287	-25.3	**
Laboratory	1,319	812	938	1,057	-19.9	*
Physical Therapy	60	14	19	8	-86.6	**
Anesthesia	449	409	352	286	-36.3	**
Respiratory Therapy	862	712	771	616	-28.5	*
EKG & EEG	7	1	1	1	-75.0	**
Other	325	670	986	884	+172.0	**
Rehabilitation	-	-	0	-	-	
Cardiology	28	86	113	98	+250.0	**
Hemodialysis	30	5	8	15	-50.0	
Catheter Lab	1,201	1,207	1,161	1,423	+18.5	
Total	14,789	12,728	12,816	11,915	-19.4	**

NOTES: Direct costs are for services directly assigned patients in the listed departments.
Excludes indirect overhead costs centers.

** = Significant at 5% level

* = Significant at 10% level

SOURCE: Developed from Micro-cost datafiles, St. Joseph Mercy Hospital.

TABLE 6-12

DRG 107 AVERAGE DIRECT COSTS PER MEDICARE PATIENT BY DEPARTMENT, 1990-1993:
ST. JOSEPH MERCY HOSPITAL, ANN ARBOR

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	66	134	185	(79)		
Nursing ICU	2,611	2,312	2,291	2,305	-11.7%	
Nursing General	1,037	908	969	847	-18.3	
Pharmacy	613	590	662	669	+9.1	
OR & Recovery	2,937	3,113	3,048	2,834	-3.5	
Radiology	286	244	284	286	0.0	
Laboratory	888	628	725	893	+0.5	
Physical Therapy	25	11	12	10	-60.0	
Anesthesia	399	406	342	306	-23.3	**
Respiratory Therapy	561	576	584	657	+17.1	
EKG & EEG	3	2	4	2	0.0	
Other	171	410	876	856	+400.5	**
Rehabilitation	-	-	-	-	-	
Cardiology	15	48	77	67	+346.6	**
Hemodialysis	30	4	23	20	-33.3	
Catheter Lab	116	45	133	167	+44.0	
Total	9,692	9,297	10,030	9,918	+2.3	

NOTES: Direct costs are for services directly assigned patients in the listed departments.
Excludes indirect overhead costs centers.

** = Significant at 5% level

* = Significant at 10% level

SOURCE: Developed from Micro-cost datafiles, St. Joseph Mercy Hospital

TABLE 6-13

DRG 106 AVERAGE COSTS, REVENUES, AND MARGINS PER DEMONSTRATION PATIENT, 1990-1993: OHIO STATE UNIVERSITY HOSPITAL, COLUMBUS

Category	June 1990-April 1991	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	53	42	73	93	-
Total Charges	$33,502	$37,502	$38,472	$41,020	+22.4 %
Total Direct Cost	**14,397**	**14,640**	**14,904**	**16,342**	**+13.5**
Total Indirect Cost	**10,987**	**11,760**	**11,479**	**11,815**	**+7.5**
Total Cost	**25,384**	**26,400**	**26,383**	**28,157**	**+10.9**
Net Revenue	28,376	23,972	23,972	23,972	-15.5
Net Income	2,992	-2,428	-2,411	-4,185	-
Direct Margin	13,979	9,332	9,068	7,630	-45.4

NOTES.

1. Direct Margin = Net Revenue - Direct Cost. Variable costs not reported separately.
2. Net Income = Net Revenue - Total Cost.
3. 1991-93 Net revenues based on HCFA negotiated rates.

SOURCE: Ohio State University Hospital Micro-Cost Accounting System.

TABLE 6-14

DRG 107 AVERAGE COSTS, REVENUES, AND MARGINS PER DEMONSTRATION PATIENT, 1990-1993: OHIO STATE UNIVERSITY HOSPITAL, COLUMBUS

Category	June 1990-April 1991	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	50	28	54	51	-
Total Charges	$27,294	$32,643	$33,606	$36,996	+35.5 %
Total Direct Cost	**11,628**	**12,534**	**12,987**	**14,834**	+27.6
Total Indirect Cost	**8,836**	**9,916**	**10,018**	**10,588**	**+19.8**
Total Cost	**20,464**	**22,449**	**23,005**	**25,442**	**+24.2**
Net Revenue	23,773	18,697	18,697	18,697	-21.4
Net Income	3,310	-3,752	-4,308	-6,725	-
Direct Margin	12,145	6,163	5,710	3,863	-68.2

NOTES

1. Direct Margin = Net Revenue - Direct Cost. Variable costs not reported separately
2. Net Income = Net Revenue - Total Cost
3. 1991-93 Net revenues based on HCFA negotiated rates

SOURCE Ohio State University Hospital Micro-Cost Accounting System

106 cost inflation was relatively modest compared with the historical rate of inpatient cost increases for bypass surgery elsewhere in the United States.

Based on the hospital's cost definitions, slightly more than half of total costs were directly attributable to departments treating patients. The direct proportion of costs rose over the demonstration period, reaching 58% in DRG 106 and 107 in 1993.

Average charges rose roughly ten percentage points faster in the hospital over the four year period. Net revenues per case, however, fell dramatically beginning with the demonstration. This was due to the deep discounts the hospital offered to the Medicare program. Thus, net revenues fell 15.5% in DRG 106 beginning in May 1991, and 21.4% for DRG 107. The hospital also agreed to forego any updates in their negotiated rates over the first three years that further added to its financial problems.

The failure to reduce costs, coupled with flat global payment rates, resulted in negative net incomes for both DRGs. For DRG 106, the hospital reported a positive net income, or average margin, of $2,992 in the year before the demonstration. In 1991, this gain turned into a loss of $2,428 that grew to $4,185 by 1993. This amounted to roughly a $7,000 turnaround in average profits. For DRG 107, the negative trend was even larger. A $3,310 profit in 1990 turned into a $6,725 loss by 1993.

Unfortunately, Ohio State University Hospital's accounting system could not decompose costs into fixed versus variable in order to determine short-run profitability. Direct cost margins were calculated instead.[1] Assuming direct costs approximate variable costs, OSU Hospital enjoyed a short-run profit of almost $14,000 on DRG 106 patients prior to the demonstration. This profit was eroded over the course of the demonstration so that by 1993, it amounted to $7,630. Because of fewer effective cost controls on DRG 107 patients, direct margins fell even more. By 1993, the hospital was covering only $3,863 of its estimated $10,588 in indirect costs.

6.6.2 Department Costs

Decomposing OSU's cost trends by department over time is fraught with difficulties. For example, costs are never separated into fixed and variable, as was mentioned above. But more limiting was the inability of the hospital to provide direct costs at the department level; only total costs after loading on overhead cost centers were available for analysis. For individual patients, only their charges by department were provided along with a global cost-

[1] According to the data furnished by the established micro-cost system in St. Joseph's Hospital in Atlanta, roughly 84% of direct patient costs are variable compared with just 24% of indirect costs. Thus, it may not be too erroneous to assume that OSU's direct cost approximate variable costs overall.

to-charge ratio that included stepped-down costs in the numerator. Cost centers were classified using a three-digit code while cost-to-charge ratios were provided initially at the four-digit level. A crosswalk was provided at a later date, but inconsistencies may remain in aligning ratios with departments.

Another problem in comparing costs over time has been the constant change in department definitions. First, new departments have been added to the three-digit listing over time. These fall into the "other costs" category, but may be drawing away costs from other departments in later years to an unknown extent. Second, broader departments such as EKG and Blood Processing are decomposed into subdepartments in later years, e.g., Holter Monitor, telemetry, blood administration. These were folded back into the broader center definitions to be consistent with earlier years, but errors may have occurred. Third, cost-to-charge ratios in a few departments appeared erroneous from year to year. For example, Medical Supplies usually had an RCC of .33, implying a tripling of prices over supply costs. In one year, however, the ratio was .98. We substituted the more common lower ratio where it seemed more reasonable. Fourth, in the operating room there was a dramatic jump in patient charges from 1991 to 1992 without a corresponding reduction in the department's cost-to-charge ratio. We did not make any adjustment as it may be due to a legitimate jump in costs and charges for OR services. Finally, the baseline sample reporting departmental costs was smaller than the one reporting overall patient costs. This appeared to produce underestimates of costs by department and overstated cost increases.

With these caveats in mind, the results on department cost trends are shown in Tables 6-15 and 6-16. The numbers in the tables are generally much higher than seen in previous tables for other hospitals that excluded indirect costs. Little systematic trends exist across departments. ICU nursing shows large increases while general nursing shows large decreases. Pharmacy costs, which seem to be less affected by accounting problems than other departments, show significant increases in both DRGs. Operating room costs appear to have exploded, but this may be due to inaccurate charge or cost-to-charge data. Catheter lab costs for DRG 106 seem particularly low given that they represent loaded costs. In any event, they show an increase of 65% over three years.

From these tables, it is impossible to draw conclusions about the impacts of any cost containment efforts in particular departments. Some of the physicians that we interviewed complained about the limitations of the hospital's cost accounting system in isolating the true costs, tests, and procedures performed on bypass patients. While the detailed data at the hospital are better than provided to the evaluator, they still suffer from too many drawbacks to be useful in monitoring performance and supporting cost effective changes in clinical behaviors.

TABLE 6-15

DRG 106 MEDICARE DEMONSTRATION AVERAGE DIRECT COSTS PER PATIENT BY DEPARTMENT, 1990-1993: OHIO STATE UNIVERSITY HOSPITAL, COLUMBUS

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	27	68	73	93		
Nursing ICU	3,531	5,147	4,604	5,406	+53.1 %	**
Nursing General	5,830	5,040	3,607	3,085	-38.8	**
Pharmacy	1,398	1,758	1,714	1,782	+27.5	**
OR & Recovery	2,540	4,284	7,117	6,791	+267.3	**
Radiology	483	623	568	566	+17.2	
Laboratory	1,860	2,019	1,492	1,590	-14.5	
Physical Therapy	125	147	182	60	-52.0	**
Anesthesia	540	333	358	403	-25.4	**
Respiratory Therapy	714	920	933	736	+3.1	
EKG & EEG	2,651	3,317	1,381	1,064	-59.9	**
Other	109	342	347	318	+191.7	
Rehabilitation	-	-	32	76	-	
Cardiology	177	254	184	330	+86.4	
Hemodialysis	-	75	6	34	-	
Catheter Lab	717	826	1,077	1,185	+65.3	**
Central Supply	599	924	1,621	2,313	+286.1	**
IV Therapy	86	110	137	247	+187.2	**
Blood Bank	414	444	1,104	1,908	+360.8	**
Total	21,774	26,563	26,464	27,894	+28.2	**

NOTES: Direct costs are for services directly assigned patients in the listed departments.
Excludes indirect overhead costs centers.

** = Significant at 5% level

* = Significant at 10% level

SOURCE: Developed from Micro-cost datafiles, Ohio State University Hosptial.

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TABLE 6-16

DRG 107 MEDICARE DEMONSTRATION AVERAGE DIRECT COSTS PER PATIENT BY DEPARTMENT, 1990-1993: OHIO STATE UNIVERSITY HOSPITAL, COLUMBUS

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	28	49	54	51		
Nursing ICU	2,374	3,447	4,059	4,544	+91.4 %	**
Nursing General	4,418	4,288	2,889	2,917	-34.0	**
Pharmacy	1,167	1,404	1,599	1,928	+65.2	**
OR & Recovery	2,597	3,993	6,755	6,494	+150.1	**
Radiology	349	490	485	577	+65.3	**
Laboratory	1,489	1,640	1,312	1,484	-0.3	
Physical Therapy	112	121	145	104	-7.1	
Anesthesia	528	385	374	414	-21.6	**
Respiratory Therapy	567	844	940	783	+38.1	
EKG & EEG	2,466	2,714	1,073	888	-64.0	**
Other	183	350	180	139	-24.0	
Rehabilitation	-	-	33	63	-	
Cardiology	57	21	50	53	-7.0	
Hemodialysis	-	153	316	17	-	
Catheter Lab	56	125	127	205	+266.1	**
Central Supply	616	921	1,595	2,204	+257.8	**
IV Therapy	47	69	90	207	+340.1	**
Blood Bank	279	532	1,066	2,375	+751.3	**
Total	17,305	21,497	23,088	25,396	+46.7	**

NOTES: Direct costs are for services directly assigned patients in the listed departments.
Excludes indirect overhead costs centers.

** = Significant at 5% level

* = Significant at 10% level

SOURCE: Developed from Micro-cost datafiles, Ohio State University Hospital.

6.7 Summary of Findings

Table 6-17 presents a summary of trends in costs and profits for the four demonstration hospitals. In three of four hospitals, average total costs per case fell in absolute terms over the 1990-93 period. The range of decline was from -2% (in St. Joseph's Mercy for DRG 107) to -23.4% (again for St. Joseph's Mercy for DRG 106). Assuming at least 5% annual inflation in input prices and ignoring secular increases in intensity, these reductions amount to even large hospital savings on a real resource basis. Ohio State University Hospital, while not actually achieving cost reductions, was successful in holding cost inflation to under 11% over a three-year period for DRG 106. The hospital appeared to be less successful in DRG 107.

Both nonacademic medical centers were quite successful in improving net income, or profits, per demonstration patient, especially in DRG 106. University Hospital less successful, although net incomes in DRG 106 fell only slightly. Ohio State University Hospital suffered significant losses compared to the year before the demonstration. This was due to a combination of very large discounts plus cost increases, especially for DRG 107.

Most important to hospital financial managers are variable margins as they reflect short-run profits. Positive variable margins mean that demonstration patients are more than covering their own direct costs and contributing to fixed costs as well. The four sites varied greatly in their definition of variable costs. In 1990, University Hospital reported variable margins of $22-23,000 per case compared with only about $5,000 per case in Atlanta. Such large differences are attributable to the Atlanta facility classifying two-thirds of its bypass costs as variable versus only one-third in Boston. Assuming that two-thirds of all costs in treating bypass patients is fixed seems unrealistically high. Most operating room, central supply, nursing, drug, catheter, lab, blood bank, and central supply costs are variable. Thus, the extraordinary variable margins at University Hospital certainly overstate short-run profits to the facility.

Within-hospital trends in variable margins under the demonstration are mixed. The two nonacademic facilities show very large increases (except for DRG 107 in Ann Arbor), implying highly successful financial outcomes. The two academic medical centers, but contrast show large, or in the case of OSU, very large declines in variable margins. Some of this change may be due to reclassifications of fixed to variable costs, but still the short-run profitability of Medicare bypass surgery, while still positive, has declined in both places. Had volumes increased significantly, thereby spreading fixed costs across more cases, the lower variable margins would have been more tolerable.

TABLE 6-17

SUMMARY OF COST AND PROFIT TRENDS: 1990-1993

	DRG 106			DRG 107		
Total Cost Per Case	1990	1993	Percent (or Dollar) Change 1990-93	1990	1993	Percent (or Dollar) Change 1990-93
St. Joseph's	22,118	20,208	-8.6 %	17,756	15,460	-12.9 %
St. Joseph Mercy	27,541	21,106	-23.4	18,235	17,865	-2.0
University Hospital, Boston	33,111	30,886	-6.7	21,471	20,621	-4.0
OSU Hospital, Columbus	25,384	28,157	+10.9	20,464	25,442	+24.2
Net Income Per Case						
St. Joseph's	-1,482	2,126	+$3,608	-891	3,513	+$4,404
St. Joseph Mercy	230	8,866	+8,636	4,135	2,868	-1,267
University Hospital, Boston	1,406	1,090	-316	9,935	6,685	-3,250
OSU Hospital, Columbus	2,992	-4,185	-7,177	3,310	-6,725	-10,035
Variable Margin						
St. Joseph's	5,685	10,295	+81.1 %	4,610	9,741	+111.1 %
St. Joseph Mercy	12,546	20,328	+62.0	12,374	12,670	+2.4
University Hospital, Boston	21,818	19,254	-11.8	23,204	18,690	-19.5
OSU Hospital, Columbus	13,979	7,630	-45.4	12,145	3,863	-68.2

SOURCE: Developed from Micro-cost files on demonstration hospitals.

7.0 IMPACT OF BUNDLED PAYMENTS ON PATIENT OUTCOMES

7.1 Introduction

A potential risk of bundled payments is that they may adversely affect the clinical outcomes of CABG surgery by introducing incentives to "skimp" on services either by reducing the intensity of care or shortening hospital lengths of stay. Another response might be for hospitals to select less severely ill patients for surgery in an attempt to maintain favorable outcomes while reducing costs. In either event, case-mix adjustment is needed to assure valid assessment the demonstration's effects and valid comparisons among hospitals and trends over time.

This chapter presents the characteristics and clinical outcomes of patients who received CABG surgery in the four original demonstration sites between May, 1991 and December, 1993 and in the three new demonstration sites between May and December, 1993. Descriptive results are presented first, followed by multivariate analysis. The patient outcomes that are analyzed include in-hospital and one-year mortality, post-operative complications, angina relief, and readmissions during the first post-operative year. Changes in hospital lengths of stay, total and post-operative, are also examined as a measure of hospital efficiency and physician behaviors. For each outcome, results are shown for the demonstration population as a whole and for individual hospitals.

7.2 Definitions of Patient Outcomes

In-hospital mortality: Deaths occurring after CABG surgery and prior to discharge from the hospital performing the surgery.

Post-operative complications: Patient-specific complications were reported in the clinical data provided by each hospital. Complication outcomes are analyzed both by type of complication and in terms of whether a patient suffered any complication. Types of complications reported include reoperation, new myocardial infarction after CABG surgery, infection, neurologic complication, pulmonary complications, renal failure, and vascular complication.

Pre- and post-operative and total length of stay during the CABG admission: Total length of stay was calculated from the date of admission to the date of discharge from the hospital performing the CABG surgery. Total length of stay was one day if the date of admission and date of discharge were the same. **Pre-operative length of stay** was calculated from the date of admission through the day before CABG surgery. **Post-operative length of**

stay was calculated from date of CABG surgery to the date of discharge. This may produce one day longer stays than reported in the clinical literature that does not count the day of surgery.

Mortality during the first year after CABG surgery: Calculated for patients operated upon in 1991 or 1992 from the date of CABG surgery through 1, 3, 6, 9, and 12 months.

Angina status one year after CABG surgery: Obtained from responses to a 12-month follow-up questionnaire completed by the four initial demonstration sites for a subset of patients undergoing surgery through December 1992. Two different definitions of angina were used: (1) simple reported angina from the follow-up form, and (2) an approximation based on whether a patient was using anti-anginal medications (nitrates, beta-blockers, calcium antagonists) at the time of follow-up.

Hospital readmissions during the year after CABG surgery: Obtained from responses to the 12-month follow-up questionnaire completed by the four initial demonstration sites for a subset of patients undergoing surgery through December 1992. Patients are classified as having any/no readmissions to any hospital during the year following surgery (multiple readmissions for an individual are not counted).

7.3 A Note on Experimental Design

It is important to remember that the results presented in this report are not generated from a randomized clinical trial. The demonstration hospitals have unique control over the patients who undergo heart bypass surgery. In addition, we do not have clinical information on patients discharged prior to the start of the demonstration that could serve as a historical control group. Hence, multivariate statistical methods are key for assessing time trends while adjusting for differences in patient severity across hospitals over time. Even with multivariate methods, however, patients discharged early on in the demonstration become the *de facto* intertemporal control group; in addressing the question of possible demonstration effects on outcomes, if significant changes in patient mortality occurred during these early months relative to the historical period, our quasi-experimental design will fail to record them fully. There is little reason to believe, however, that surgeons and the rest of the clinical staffs at these facilities responded immediately to the reimbursement incentives, if at all, in ways detrimental to patients.

7.4 Data Sources

7.4.1 Clinical Data

Two forms were developed to guide the collection of clinical data in the demonstration sites. The first of these instruments was designed to obtain all clinical data needed to adjust for case-mix differences among hospitals in analyzing clinical outcomes and the appropriateness of CABG surgery. Information is collected on the patients' demographic characteristics, medical history, physical examination, cardiac catheterization data (including left ventricular function and coronary artery anatomy), pre-operative risk assessment, operative data, post-operative course, in-hospital mortality, and discharge disposition.

The second data collection form was directed at obtaining information on symptoms and clinical events during the 12 months following discharge. This information was intended to allow analysis of longer-term clinical outcomes that are important measures of the effectiveness of CABG surgery. The follow-up form included information on mortality within one year following discharge, readmissions within the same period, anginal status, and use of medications. Copies of both data collection instruments can be found in Appendix 7.

Development of the data collection forms was influenced by three considerations:

1. the need for information to adjust clinical outcomes for relevant differences in casemix;

2. the goal of developing a database that would permit valid comparisons among demonstration sites; and

3. the desire to make maximum possible use of existing cardiac catheterization and cardiac surgery registries, in an effort to reduce the data collection burden on the sites.

A "standardized" cardiac surgery registry format already in place in the participating surgery programs would have been ideal, but was not possible since existing registries varied widely both in content and stage of development. Moreover, none of the programs monitored long-term outcomes systematically. We therefore developed data collection instruments specifically for the demonstration, making maximum possible use of available registry formats such as that developed by the Society of Thoracic Surgeons for a National Cardiac Surgery Database. Both forms were subjected to several rounds of review by participating surgical programs and were modified in response to comments received. They were also pre-tested in a sample of patients from each site.

7.4.2 HCFA Denominator File

The Medicare Enrollment or Denominator, Files for 1991, 1992, and 1993 provided a third source of data. These files contain demographic and eligibility information on all Medicare enrollees. They were used in this analysis as supplements to the one-year follow-up data on Medicare enrollee deaths and dates of death.

Reliance only on survey data for one-year mortality would mean that our analysis of this important outcome measure would be limited to the relatively small pool of patients for whom follow-up surveys were completed. The evaluation team was provided access to the Denominator files upon the approval of Project Officer, Armen Thoumaian, Ph.D.

7.4.3 Data Collection and Management

Clinical data collection instruments were distributed to the sites in early 1992, and schedules for data submission were established that aimed, first, to catch up with the backlog of patients operated upon since the demonstration began in mid-1991 and, then, to remain current.

Demonstration sites were encouraged to collect and submit data by whatever method would impose the least burden on hospital staff. Each hospital responded differently. Hospital D chose to complete the clinical data collection form manually, and submitted hard copies of the collection instrument to the evaluation team. All other sites submitted their data in electronic form. Hospital B modified its computerized registry to include the additional items required by our instrument; Hospital C developed a supplement to its existing registry and forwarded data electronically; and Hospital A developed a computerized registry modeled after our instrument. Data received by the evaluation team from Hospitals A, D, E, F, and G were virtually identical in format to our data collection instrument, and were similar in the case of Hospital B, but required considerable reformatting in the case of Hospital C.

Follow-up data collection instruments were distributed to the original four sites in 1992, and have been received for patients discharged prior to January 1993, allowing a full year's follow-up. No follow-up data has yet been received from the newest three sites, as they came into the demonstration only in mid-1993. The condition of the follow-up data from the original four sites varied substantially. Hospitals A and D sent hardcopies of the actual data instrument. Hospital C used a different format that omitted key variable, anginal status. Hospital B sent its follow-up data in a format requiring a great deal of computer re-formatting, and did not have a uniform one-year follow-up time period. The condition of the follow-up

data from Hospital B suggested to the evaluation team that it was the least reliable of the one-year follow-up data.

7.4.4 Data Cleaning and Problem Resolution

Consistency and reasonability tests were conducted to assure the validity of the data collected from the demonstration hospitals. Three types of problems were addressed in cleaning the data: 1) invalid characters/miscoding; 2) inconsistency between related questions; and 3) clinical infeasibility. Missing data will be discussed in a separate section due to their important implications for the analysis. Invalid characters appeared in the electronically transmitted data sets (Hospitals A, B and C) as a result of human error in the original coding of the data or in the conversion programs used to translate the data into analytic files. These errors were detected through the examination of the response frequencies for each variable. Appropriate steps were taken to recode the data after consulting with the demonstration hospitals where necessary. Several items in the clinical data collection instrument relate to a previous item either directly or indirectly. For example, item C-1 asks for the patient's clinical presentation at the point of CABG hospitalization (stable angina, unstable angina, acute MI); item C-3 then asks "If patient was admitted with an acute MI, time from onset of MI to date of CABG surgery" (less than 7 days, etc.). In several cases, either the response to the second part of the question was inconsistent with the first part (e.g., a patient presented with stable angina and less than seven days was circled for C-3) or the first part of the response was missing. In the former case, other indicators were examined for evidence of which part of the clinical record was in error and the responses were made internally consistent. In the latter case, an imputation was made where there was a high degree of certainty that the missing data could be filled in accurately. In some cases, however, we were unable to resolve apparent contradictions in the data. For example, Hospital D classified 37.5 percent of its patients as undergoing CABG surgery on an elective basis, but also recorded clinical presentation as unstable angina for 79.1 percent. According to our clinical definition of unstable angina, these results are conflicting. We were unable to make a retrospective adjustment to the data without further information.

Infeasible responses were encountered most often in items that required the respondent to "circle all that apply". For example, question H-4 requests information regarding the type of myocardial protection used and lists six possible answers, of which the respondent may select all that apply. However, clearly "intermittent cross-clamp" and "continuous perfusion/no cross-clamp" are mutually exclusive. In cases where such a response was encountered, the response was recoded as "don't know" for the purpose of analysis.

7.4.5 Missing Data

Because of the potential for biased results, missing data were explored at length. In our First Year Report we noted that initial results indicated that missing data might be a significant problem. At that time, a letter was sent to the participating hospitals detailing those areas identified to be a problem with that hospital's data collection efforts. In particular, the importance of accurate reporting of variables judged *a priori* to be significant risk factors was emphasized.

In some cases, missing responses were a result of the ambiguity of the data instrument or a misunderstanding on the part of the respondent. For example, question I-4 asks the respondent whether the patient suffered post-operative complications. The instrument directs the respondent to answer the rest of the section on the nature of the complications if, and only if, the answer to I-4 is 'yes'. Death in the hospital is the last item in the complications section. In a few instances, missing values for death occurred because the respondent did not interpret death as a complication. In these cases, a phone conversation resolved the matter. Similar conversations indicated that under certain circumstances missing values for other variables (e.g., comorbid conditions) could be interpreted as 'no's. Imputations were made accordingly. Unfortunately, there were a large number of missing values for which no imputation could be made. Missing data percentages are shown in the descriptive tables.

One-year follow-up data were not available for all demonstration patients, and often contained missing values of important variables for those patients who were followed-up. As noted earlier, Hospital C omitted anginal status from its questionnaire. Low response rates for follow-up data led us to use the Medicare Enrollment Files for information on one-year mortality, the key outcome variable for the follow-up analysis.

Patients missing any of the independent risk adjusters are automatically dropped from the multivariate analysis. The existence of a significant quantity of missing data raises a basic question with regard to the validity of the results: are those patients excluded from our final analysis due to missing data systematically different from the patients who remain in the sample, and if so, how are they likely to differ?

Following the interim report, efforts were made to gather the missing data for all variables for which missing data presented a problem. These efforts were generally successful, particularly with regard to ejection fraction, which went from 34.8 percent missing in the interim report to 10.5 percent missing in this report, and height, which went from 24.5 percent missing to 2.3 percent.

At the time of the interim report, we conducted an extensive analysis of the patient records for which key data fields were missing. The general finding was that the pool of

patients missing a key data field (i.e., clinical presentation, revascularization priority, or ejection fraction) was a healthier population then that for which we had complete data, with fewer comorbid risk factors. So that the reader may assess the degree to which missing data continue to affect the analysis, mortality rates for patients missing each key data field are reported along with each field's stratified mortality rates. A brief examination appears to validate the interim finding that missing-data records represent a relatively healthy subgroup. Mortality rates appear relatively low among those missing clinical presentation, ejection fraction, several comorbid variables, and height. Presuming that the missing-data group is, in fact, a healthier group, the effect of its exclusion from the analysis would be to overstate mortality.

7.5 Descriptive Results

7.5.1 Volume Trends in Demonstration Sites

Table 7-1 shows Medicare patient volumes for DRGs 106 and 107 for the first two and a half years of the demonstration overall and by hospital. Results are presented for the four original sites for the entire period from May 1991 through December 1993 and for the three new sites from May through December 1993. Figures for May and June of the start-up years were incomplete because hospitals were phasing in during these periods. Presumably, the major reassignment of DRG 108 CABG patients to DRG 106 or 107 occurred between 1990 and 1991 and does not affect the 1991-93 trends.

A total of 4,150 Medicare patients had been enrolled in the demonstration by December 31, 1993 including 1,854 in DRG 106 (44.7 percent) and 2,296 in DRG 107 (55.3 percent). DRG 106 enrollment increased from 37.4 percent of the total in 1992 to 47.8 percent in 1993. The pattern toward an increase in the proportion of patients in DRG 106 was consistent in all four initial sites. Patients in DRG 106 exceeded those in DRG 107 during the latter half of 1993 in all three new sites.

CABG volumes in the four initial sites in 1992, the first full year of data, ranged from 121 in the smallest participant to 640 in the largest and from 142 to 672, respectively, in 1993 in the same hospitals. All four hospitals increased their volumes between 1992 and 1993 with increases ranging from 5 percent to 25.7 percent. Volumes for July-December, 1993, in all seven hospitals ranged from 66 to 308.

TABLE 7-1

MEDICARE DEMONSTRATION PATIENT VOLUME BY HOSPITAL, DRG, AND PERIOD

	HOSPITAL A (N = 591)			HOSPITAL B (N = 1,736)			HOSPITAL C (N = 909)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
	DRG 106	DRG 107	Total	DRG 106	DRG 107	Total	DRG 106	DRG 107	Total	DRG 106	DRG 107	Total	DRG 106	DRG 107	Total	DRG 106	DRG 107	Total	DRG 106	DRG 107	Total	DRG 106	DRG 107	Total
1991																								
May-December *	**62**	**73**	**135**	**136**	**268**	**404**	**91**	**80**	**171**	**43**	**30**	**73**										**332**	**451**	**783**
1992																								
January-June	40	65	105	111	234	345	78	76	154	37	22	59										266	397	663
July-December	36	63	99	111	184	295	75	98	173	33	29	62										255	374	629
Total 1992	***76***	***128***	***204***	***222***	***418***	***640***	***153***	***174***	***327***	***70***	***51***	***121***										***521***	***771***	***1,292***
1993																								
January-June	51	83	134	125	239	364	127	80	207	47	29	76	18	27	45	11	13	24	19	21	40	398	492	890
July-December	46	72	118	114	194	308	122	82	204	46	20	66	111	102	213	79	68	147	64	41	105	582	579	1,161
Total 1993	***97***	***155***	***252***	***239***	***433***	***672***	***249***	***162***	***411***	***93***	***49***	***142***	***129***	***129***	***258***	***90***	***81***	***171***	***83***	***62***	***145***	***980***	***1,071***	***2,051***
Increase 1992-93	28%	21%	24%	8%	4%	5%	63%	-7%	26%	33%	-4%	17%										88%	39%	59%
N Missing Date of CABG				*17*	*2*	*19*				*2*	*1*	*3*				*1*		*1*	*1*		*1*	*21*	*3*	*24*
TOTAL	**235**	**366**	**591**	**614**	**1,121**	**1,735**	**493**	**416**	**909**	**208**	**131**	**339**	**129**	**129**	**258**	**91**	**81**	**172**	**84**	**62**	**146**	**1,864**	**2,296**	**4,160**

* Includes July through December for all sites, May and June depending on the hospital (see text)

SOURCE: Abstracts of clinical records among seven demonstration hospitals, May, 1991 through December, 1993.
Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993.

7.5.2 In-Hospital Mortality

Table 7-2 presents unadjusted in-hospital mortality rates for 6-month time periods during the demonstration. Overall mortality across all hospitals and periods averaged 4.3 percent. The range for initial sites during the first two and a half years was from 4.1 percent in Hospital C to 4.9% in Hospital A. Mortality in the new sites during the latter half of 1993 ranged from 0.7 percent in Hospital G to 5.0 percent in Hospital E. DRG 106 mortality was more than twice that for DRG 107 (6.2 percent vs. 2.7 percent; odds ratio 2.3). As DRG mix varies greatly by hospital, care should be taken in comparing mortality rates based on overall averages of the two DRGs.

No obvious time trend is evident in in-hospital mortality during the demonstration in the initial sites. The low mortality rate for Hospital G during 1993 may reflect random good fortune due to relatively small sample sizes.

7.5.3 In-Hospital Mortality Stratified By Patient Demographic Characteristics

Table 7-3 presents the age, sex, and race distributions of patients for each hospital and the associations of these demographic characteristics with in-hospital mortality. The mean age for the population is 69.1 years. Overall, the distribution between age groups 65-69, 70-74, and 75 and over is approximately equal. Hospital C had the highest proportion of patients 75 years of age or older (35.5 percent) and Hospital D had the lowest (23 percent).

In-hospital mortality increased directly with age from 2.8 percent in individuals 65-69 years of age to 6.3 percent in those 75 years of age or older (odds ratio 2.3). Age-related patterns vary among hospitals but mortality is uniformly highest in the oldest age group.

Male patients outnumbered females by two to one. The proportion of male patients ranged from a low of 61.9 percent in Hospital A to 73.3 percent in Hospital G. Mortality was considerably higher in females than in males (5.7 percent vs. 3.6 percent; odds ratio 1.6). Higher mortality in females was found in all hospitals except Hospital A.

White patients predominated, making up 92 percent of demonstration patients. 2.7 percent were black and 5.3 percent were hispanic or other races. The proportion of white patients ranged from 77.7 percent in Hospital A to 97.4 percent in Hospital D. In-hospital mortality was slightly higher in blacks than in whites (5.4 percent vs. 4.4 percent). Interestingly, the "other races" category exhibited lower mortality than whites (2.7 percent vs. 4.4 percent).

TABLE 7-2

IN-HOSPITAL MORTALITY BY HOSPITAL, DRG AND PERIOD

	HOSPITAL A (N = 691)			HOSPITAL B (N = 1,735)			HOSPITAL C (N = 909)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
	DRG 106 (%)	DRG 107 (%)	Total (%)	DRG 106 (%)	DRG 107 (%)	Total (%)	DRG 106 (%)	DRG 107 (%)	Total (%)	DRG 106 (%)	DRG 107 (%)	Total (%)	DRG 106 (%)	DRG 107 (%)	Total (%)	DRG 106 (%)	DRG 107 (%)	Total (%)	DRG 106 (%)	DRG 107 (%)	Total (%)	DRG 106 (%)	DRG 107 (%)	Total (%)
1991																								
May-December *	**9.7**	**4.1**	**6.7**	**6.6**	**1.9**	**3.5**	**2.2**	**3.7**	**2.9**	**0.0**	**3.3**	**1.4**										**5.1**	**2.7**	**3.7**
1992																								
January-June	2.5	6.2	4.8	6.3	1.7	3.2	3.8	1.3	2.6	10.8	4.5	8.5										5.6	2.5	3.8
July-December	16.7	1.6	7.1	9.0	3.8	5.8	2.7	5.1	4.0	6.1	3.4	4.8										7.8	3.7	5.4
Annual Average	***9.2***	***3.9***	***5.9***	***7.7***	***2.6***	***4.4***	***3.3***	***3.4***	***3.4***	***8.6***	***3.9***	***6.6***										***6.7***	***3.1***	***4.6***
1993																								
January-June **	11.8	0.0	4.5	7.2	5.4	6.0	7.1	2.5	5.3	4.3	3.4	3.9	11.1	3.7	6.7	0.0	0.0	0.0	0.0	0.0	0.0	7.0	3.5	5.1
July-December	4.4	0.0	1.7	7.0	3.1	4.5	6.6	2.4	4.9	6.5	0.0	4.5	8.1	1.0	4.7	5.1	0.0	2.7	1.6	0.0	1.0	6.0	1.6	3.8
Annual Average ***	***8.2***	***0.0***	***3.2***	***7.1***	***4.4***	***5.4***	***6.8***	***2.5***	***5.1***	***5.4***	***2.0***	***4.2***	***8.5***	***1.5***	***5.0***	***4.4***	***0.0***	***2.3***	***1.2***	***0.0***	***0.7***	***6.4***	***2.4***	***4.3***
TOTAL	8.9	2.2	4.9	7.0	3.1	4.5	4.9	3.1	4.1	5.3	3.1	4.4	8.5	1.5	5.0	4.4	0.0	2.3	1.2	0.0	0.7	6.2	2.7	4.3

* Includes July through December for all four original sites, May and June depending on the hospital (see text)

** Includes only April through June for Hospitals E, F, and G

*** The annual average for Hospitals E, F, and G represents an average of April through December only. Annual rates are not simple averages of each half-year; the rates are weighted by the number of patients in each half-year.

SOURCE: Abstracts of clinical records among seven demonstration hospitals, May, 1991 through December, 1993.
Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993.

TABLE 7-3

IN-HOSPITAL MORTALITY BY DEMOGRAPHIC CHARACTERISTIC, ALL YEARS COMBINED

	HOSPITAL A (N = 591)			HOSPITAL B (N = 1,735)			HOSPITAL C (N = 909)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
Characteristic	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio
Age																								
Under 65	6 8	0 0	0 0	9 5	4 9	1 2	5 1	2 2	1 8	13 3	6 7	7 4	7 4	5 3	2 7	4 7	0 0	0 0	0 0	0 0	N/A	7 8	4 0	1 4
65-69	26 1	4 6	1 0	31 2	4 1	1 0	35 5	1 2	1 0	33 9	0 9	1 0	38 8	2 0	1 0	31 4	1 9	1 0	35 6	0 0	N/A	32 3	2 8	1 0
70-74	34 0	4 0	0 9	33 8	3 5	0 9	23 9	5 1	4 3	24 8	6 0	6 7	26 0	4 5	2 3	32 0	3 8	1 9	35 6	0 0	N/A	31 9	4 2	1 5
75+	32 8	7	1 8	25 4	5 4	1 3	35 5	6 5	5 4	23 0	8 4	7 1	27 9	9 7	4 9	32 0	1 6	0 9	28 6	2 4	N/A	27 6	6 3	2 3
Missing	0 3	0 0	0 0	0 1	0 0	0 0	0 0	0 0	0 0	5 0	5 9	8 8	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	N/A	0 5	4 8	1 7
Mean Age	71 4			66 4			71 4			69 2			70 6			71 8			71 8			69 1		
Sex																								
Male	61 9	5 2	1 0	66 4	3 6	1 0	70 1	3 9	1 0	63 7	2 8	1 0	67 8	4 8	1 0	70 4	0 8	1 0	73 3	0 0	N/A	66 8	3 6	1 0
Female	38 1	4 4	0 8	33 6	8 5	1 8	29 9	4 4	1 1	36 3	7 3	2 6	32 2	6 0	1 3	29 7	5 9	7 4	26 7	2 8	N/A	33 2	5 7	1 6
Missing	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	N/A	0 0	0 0	0 0
Race																								
White	77 7	5 5	1 0	96 0	4 4	1 0	95 8	4 1	1 0	97 4	4 6	1 0	85 3	5 5	1 0	81 4	2 1	1 0	92 5	0 7	1 0	92 0	4 4	1 0
Black	1 4	12 5	2 3	2 9	5 9	1 3	1 9	5 9	1 4	2 7	0 0	0 0	5 8	0 0	0 0	1 7	33 3	15 9	6 2	0 0	0 0	2 7	5 4	1 2
Other	21 0	2 4	0 4	1 0	11 1	2 5	2 5	4 3	1 0	0 0	0 0	0 0	8 9	4 3	0 8	11 0	0 0	0 0	1 4	0 0	0 0	5 3	2 7	0 8
Missing	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

N/A = indicates statisbc not applicable/not meaningful.

NOTE: Percent distribution may not sum to 100 because of rounding

SOURCE: Abstracts of clinical records from seven demonstration hospitals, May-June, 1991 through December, 1993. Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993

7.5.4 In Hospital Mortality Stratified By Clinical Presentation and Pre-Operative Course

Table 7-4 presents the associations of previous CABG surgery, patient's clinical presentation to the hospital, and selected pre-operative course variables to in-hospital mortality. The clinical data collection instrument defined three priority levels for CABG surgery:

- elective: patient is clinically stable and does not require Revascularization within the next 7 days;
- urgent: patient may be unstable, have disease that warrants revascularization within 7 days, or be stable but have suffered a complication or event within the past 24 days that substantially increases the risk of revascularization (e.g. AMI);
- emergent: patient is unstable, and his/her condition requires revascularization within 24 hours.

Nearly half of patients (45.6 percent) were operated on for a clinical presentation classified as unstable angina; 25 percent of patients had stable angina; and 23.5 percent of patients were operated on during an admission an acute myocardial infarction. Patterns of clinical presentation varied dramatically among hospitals. For example, Hospital B operated upon only 5.3 percent of patients with stable angina versus 56.1 percent of patients with unstable angina; by contrast, Hospital F operated on 67.4 percent of patients with stable angina and only 9.9 percent with unstable angina. Other hospitals exhibited intermediate patterns. These differences almost certainly reflect varying definitions of unstable angina, at least in part.

Thresholds for operating on patients soon after their AMIs appear to vary widely. Only 11.5 percent of patients operated upon at Hospital D had been admitted with an AMI compared to 42.3 percent in Hospital E and 42.5 percent in Hospital G. The latter hospitals either admit more AMIs, operate on a higher proportion of those who are admitted, or both.

In-hospital mortality increased from 2.5 percent in patients with stable angina to 4.9 percent (odds ratio 2.0) and 5.7 percent (odds ratio 2.3), respectively, in patients with unstable angina or AMI. This same pattern is consistent among all hospitals.

Revascularization priority and pre-operative insertion of an intra-aortic balloon pump (IABP) describe aspects of the preoperative course. Both were strongly associated with in-hospital mortality. Overall, 60.5 percent of patients underwent elective surgery, 26 percent urgent surgery, and 11.8 percent emergent surgery. The proportion of patients undergoing emergent surgery ranged from 7 percent in Hospital E to 15.2 percent in Hospital B. An

TABLE 7-4

INPATIENT MORTALITY BY CLINICAL PRESENTATION AND PRE-OPERATIVE COURSE, ALL YEARS COMBINED

	HOSPITAL A (N = 591)			HOSPITAL B (N = 1,735)			HOSPITAL C (N = 909)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
Characteristic	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio
Clinical Presentation																								
Asymptomatic CAD	0.9	0.0	0.0	8.2	2.1	1.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	4.1	0.0	0.0	3.9	1.9	0.8
Stable Angina	31.0	2.2	1.0	5.3	2.2	1.0	58.2	2.7	1.0	8.9	3.3	1.0	12.4	3.1	1.0	67.4	2.6	1.0	38.4	1.8	1.0	25.0	2.5	1.0
Unstable Angina	51.3	5.6	2.5	56.1	4.9	2.2	24.0	5.1	1.9	79.1	4.5	1.4	34.9	4.4	1.4	9.9	0.0	0.0	14.4	0.0	0.0	45.6	4.9	2.0
Acute MI	14.6	9.3	4.2	28.2	5.1	2.3	17.8	7.4	2.7	11.5	5.1	1.5	42.3	6.4	2.1	14.5	4.0	1.5	42.5	0.0	0.0	23.5	5.7	2.3
Missing Data	2.4	0.0	0.0	2.1	2.8	1.3	0.0	0.0	0.0	0.3	0.0	0.0	10.5	3.7	1.2	4.1	0.0	0.0	0.7	0.0	0.0	2.1	2.3	0.9
Revascularization Priority																								
Elective	41.8	1.6	1.0	61.7 *	3.5	1.0	31.1	1.8	1.0	37.5	1.6	1.0	87.6 *	4.0	1.0	84.3	2.8	1.0	45.9	0.0	N/A	60.5	3.0	1.0
Urgent	46.5	5.5	3.4	1.8	0.0	0.0	59.1	4.5	2.5	54.3	5.4	3.4	5.4	7.1	1.8	5.2	0.0	0.0	20.6	0.0	N/A	26.0	4.6	1.5
Emergent	10.3	13.1	8.2	15.2	11.0	3.1	9.8	9.0	5.0	7.7	11.5	7.2	7.0	16.7	4.2	8.7	0.0	0.0	11.6	5.9	N/A	11.8	10.6	3.5
Missing Data	1.4	25.0	15.6	1.4	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	21.9	0.0	N/A	1.7	2.9	1.0
Pre-operative Insertion of IABP																								
Yes	7.1	19.1	5.0	1.7	33.3	8.1	1.3	33.3	9.0	5.6	10.5	2.6	0.0	0.0	0.0	0.0	0.0	0.0	4.8	14.3	NA	2.6	22.7	6.0
No	92.9	3.8	1.0	98.3	4.1	1.0	98.7	3.7	1.0	94.4	4.1	1.0	100.0	5.0	1.0	100.0	2.3	1.0	95.2	0.0	NA	97.4	3.8	1.0
Missing Data	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA	0.0	0.0	0.0
Previous CABG																								
Yes	8.8	7.7	1.7	9.2	11.9	3.1	10.9	9.1	2.6	5.3	11.1	2.7	27.9	13.9	8.7	14.5	4.0	1.9	13.0	0.0	0.0	13.3	8.3	2.2
No	91.2	4.6	1.0	90.8	3.8	1.0	89.1	3.5	1.0	94.4	4.1	1.0	72.1	1.6	1.0	82.6	2.1	1.0	87.0	0.8	1.0	86.5	3.7	1.0
Missing Data	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0

N/A = indicates statistic not applicable/not meaningful.

* Elective percentage inconsistent with high percent of cases with unstable angina or AMI within two weeks.

NOTE: Percent distribution may not sum to 100 because of rounding.

SOURCE: Abstracts of clinical records among four demonstration hospitals, May-June, 1991 through December, 1993.
Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993.

emergent CABG operation conveyed a mortality risk 3.5 times that of an elective procedure (mortality 10.6 percent v. 3.0 percent). Urgent procedures were intermediate (4.6 percent).

Pre-operative use of an intra-aortic balloon pump (IABP) was a very strong risk indicator (mortality 22.7 percent vs. 3.8 percent; odds ratio 6.0). The IABP is inserted into the femoral artery up to the ascending aorta to help improve the blood flow in patients with very poor left ventricular function. It is used only for the sickest of patients, and involves a high risk of infection.

A previous CABG operation had been performed in 13.3 percent of patients, ranging from a lower of 5.3 percent in Hospital D to 27.9 percent in Hospital E. Overall, in-hospital mortality was 8.3 percent in patients with a previous bypass operation and 3.7 percent in those without one (odds ratio 2.2). In-hospital mortality in "redo CABGs" ranged from 0 percent in Hospital G and 7.7 percent in Hospital A to 13.9 percent in Hospital E.

7.5.5 In-Hospital Mortality Stratified by Severity of Coronary Artery Disease

Coronary artery anatomy and left ventricular ejection fraction, respectively, are used to describe the extent of coronary artery disease and its effects on heart function. "Critical" obstructions of the coronary arteries were defined as greater than or equal to 70 percent of the cross-sectional diameter for the left, right and circumflex coronary arteries and greater than or equal to 50 percent for the left main coronary artery (LMCA).

Overall, 20.6 percent of patients had LMCA disease (see Table 7-5), 32.3 percent had three-vessel disease, 27.4 percent had two-vessel disease, 11.0 percent had disease in only a single vessel, and less than one percent had no critical lesions.

Coronary angiography data were missing in 7.8 percent of patients, most of whom were operated upon in Hospital B. Another way to look at the extent of coronary artery disease is in terms of the total number of "critical" obstructions, regardless of their locations. Three or more critical obstructions were found in 58.7 percent of patients after excluding those with LMCA disease or missing data.

In-hospital mortality was slightly higher in patients with LMCA disease (5.5 percent) than in other patients (4.1 percent). Patients with three-vessel disease had a higher in-hospital mortality than those with two-vessel or single vessel disease (4.8 percent vs. 3.7 percent and 3.5 percent, respectively).

Questions about the appropriateness of CABG surgery arise especially in patients with no critical lesions or single vessel disease. Angioplasty is generally the treatment of choice in the latter group if the obstruction is less than 1.5 cm in length and accessible to the balloon

TABLE 7-5

INPATIENT MORTALITY BY CORONARY ARTERY ANATOMY AND EJECTION FRACTION, ALL YEARS COMBINED

Charactenstic	HOSPITAL A (N = 591)			HOSPITAL B (N = 1,735)			HOSPITAL C (N = 903)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio
Coronary Artery Anatomy																								
Left Main Coronary Artery Disease (> = 50% Stenosis)																								
Yes	23.0	5.1	1.0	22.7	5.8	1.3	20.5	5.4	1.5	15.3	3.9	0.9	25.6	7.6	1.6	11.1	0.0	0.0	0.7	0.0	0.0	20.6	5.5	1.3
No	72.8	5.2	1.0	64.9	4.4	1.0	74.6	3.5	1.0	84.7	4.5	1.0	66.7	4.7	1.0	77.9	3.0	1.0	99.3	0.7	1.0	71.8	4.1	1.0
Disease in LAD, RCA, and CX among Patients without Critical Stenosis in LMCA Number of Vessels w/ Stenosis > = 70%																								
0.0	1.2	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	9.9	0.0	0.0	0.7	0.0	0.0	0.9	0.0	0.0
1.0	9.8	3.5	1.0	11.1	4.2	1.0	12.1	2.7	1.0	9.1	0.0	0.0	5.8	20.0	1.0	22.1	0.0	0.0	7.5	0.0	0.0	11.0	3.5	1.0
2.0	30.1	5.1	1.5	24.5	2.8	0.7	29.9	3.3	1.2	28.3	7.3	1.0	24.0	3.2	0.2	29.1	4.0	1.0	37.0	1.9	1.0	27.4	3.7	1.1
3.0	31.6	5.9	1.7	28.9	6.0	1.4	32.1	4.1	1.5	47.2	3.8	0.5	36.4	3.2	0.2	16.9	6.9	1.7	54.1	0.0	0.0	32.3	4.8	1.4
Number of Obstructions w/ Stenosis > = 70%																								
0.0	1.2	0.0	0.0	0.5	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	9.9	0.0	0.0	0.7	0.0	0.0	0.9	0.0	0.0
1.0	8.1	4.2	1.0	9.0	3.9	1.0	10.3	3.2	1.0	5.0	0.0	0.0	4.3	27.3	1.0	17.4	0.0	0.0	7.5	0.0	0.0	8.8	3.8	1.0
2.0	21.0	5.7	1.4	19.7	2.9	0.7	23.9	3.7	1.0	15.3	5.8	1.0	8.9	4.4	0.2	23.3	0.0	0.0	19.9	1.0	1.0	19.9	3.4	0.9
3+	42.5	5.2	1.2	35.9	5.5	1.4	39.9	3.9	1.2	64.3	4.6	0.8	53.1	2.9	0.1	27.3	8.5	1.0	71.2	0.0	0.0	42.0	4.6	1.2
Missing all Coronary Anatomy Data	4.2	0.0	0.0	12.3	2.8	0.6	5.0	6.7	1.9	0.0	N/A	N/A	7.8	0.0	0.0	11.1	0.0	0.0	0.0	N/A	N/A	7.8	2.8	0.7
Left Ventricular Ejection Fraction																								
Less than 26	3.2	21.1	4.7	4.5	9.0	3.3	12.4	5.3	1.8	1.2	25.0	7.6	7.4	10.5	2.9	0.6	0.0	0.0	4.1	0.0	NA	5.8	8.3	2.6
26 - 34	6.9	14.6	3.2	4.4	7.9	2.9	2.6	0.0	0.0	6.5	4.6	1.4	4.6	0.0	0.0	4.1	14.3	4.1	4.8	0.0	NA	4.6	7.4	2.3
35 - 49	20.1	2.5	0.6	29.3	7.3	2.7	54.6	4.6	1.5	21.2	6.9	2.1	24.4	7.9	2.2	9.9	0.0	0.0	16.4	0.0	NA	31.3	5.6	1.8
50+	56.5	4.5	1.0	53.8	2.7	1.0	28.9	3.0	1.0	63.1	3.3	1.0	53.5	3.6	1.0	49.4	3.5	1.0	13.0	0.0	NA	47.9	3.2	1.0
Missing data	13.2	1.3	0.3	8.0	2.9	1.1	1.4	0.0	0.0	8.0	3.7	1.1	10.0	3.8	1.1	36.1	0.0	0.0	61.6	1.1	NA	10.5	1.9	0.6
Mean Ejection Fraction	53.5			48.5			41.8			56.4			54.2			47.8			40.3			48.5		

N/A = indicates statistic not applicable/not meaningful

NOTE Percent distribution may not sum to 100 because of rounding

SOURCE Abstracts of clinical records among four demonstration hospitals, May-June, 1991 through December, 1993
Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993

catheter. Detailed examination of the coronary artery anatomy and other patient characteristics are used to determine the appropriateness of surgery in Chapter 8.

Left ventricular ejection fraction (LVEF) reflects the proportion of blood expelled by the heart during each contraction. A normal LVEF is 50 percent or higher while anything less than 25 percent indicates severely compromised cardiac function. Data on LVEF were missing in 10.5 percent of patients, including 61.6 percent of patients in Hospital G and 36 percent of patients in Hospital F. In patients with data, 47.9 percent had a normal LVEF, and 10.3 percent had values of less than 35 percent. Mortality showed a graded relationship to ejection fraction, increasing from 3.2 percent in patients with LVEF of 50 percent or greater to 8.3 percent in those with LVEF of less than 2.5 percent or less (odds ratio 2.6). Patients with missing data had a mortality rate consistent with patients with normal ejection fractions.

7.5.6 In-Hospital Mortality Stratified By Presence of Comorbidities

The effects of comorbid diseases on mortality are shown in Table 7-6. Chronic renal failure (CRF), defined as a serum creatinine greater than 2.0 mg percent, and a clinical diagnosis of congestive heart failure (CHF), had the strongest associations with in-hospital mortality (the definition of CHF can be found in the data collection instrument in Appendix 7). Patients with CRF or CHF had mortality rates 2.6 and 2.3 times higher, respectively, than patients without these conditions. Mortality rates in patients with a prior stroke or TIA or diabetes mellitus were 1.6 times higher. The presence of hypertension or chronic pulmonary disease were less strongly associated with in-hospital mortality.

7.5.7 In-Hospital Mortality Stratified By Height and Body Mass Index

The associations of height and body mass index to in-hospital mortality are shown in Table 7-7. Mortality in patients less than 1.65 meters in height is 1.9 times that of patients 1.75-1.84 meters in height. The relationship to height is a graded one between these extremes. Body mass index, calculated as the weight in kilograms divided by height squared in meters, provides a measure of relative obesity. No clear association was seen between body mass index and mortality. If anything, individuals with body mass indices of 35 or higher appear to have lower mortality (odds ratio 0.3 vs. BMI of 20-24).

TABLE 7-6

IN-HOSPITAL MORTALITY BY PATIENT CO-MORBIDITIES, ALL YEARS COMBINED

	HOSPITAL A (N = 591)			HOSPITAL B (N = 1,735)			HOSPITAL C (N = 909)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
Characteristic	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio
Chronic Renal Failure																								
Yes	9.9	15.3	3.9	14.5	8.4	2.2	4.4	15.0	3.9	9.7	9.1	2.3	9.7	8.0	1.7	4.7	0.0	0.0	0.7	0.0	0.0	10.0	9.8	2.8
No	86.5	3.9	1.0	85.5	3.9	1.0	84.0	3.8	1.0	89.7	4.0	1.0	90.3	4.7	1.0	95.4	2.4	1.0	99.3	0.7	1.0	86.9	3.7	1.0
Missing Data	3.6	0.0	0.0	0.0	0.0	0.0	11.5	1.9	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	1.6	0.4
Congestive Heart Failure																								
Yes	25.7	8.6	2.4	11.7	8.4	2.0	11.7	8.5	2.4	8.6	10.3	2.6	14.3	10.8	2.6	9.9	0.0	0.0	0.0	0.0	0.0	13.1	8.5	2.3
No	74.3	3.6	1.0	88.3	4.1	1.0	88.3	3.5	1.0	91.5	3.9	1.0	85.7	4.1	1.0	90.1	2.6	1.0	100.0	0.7	1.0	86.9	3.7	1.0
Missing Data	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stroke																								
Yes	12.0	8.5	1.8	8.2	6.3	1.4	8.0	4.1	1.0	10.6	8.3	2.1	8.5	13.6	3.2	7.6	0.0	0.0	0.0	0.0	NA	8.6	6.7	1.6
No	84.6	4.6	1.0	91.8	4.4	1.0	81.4	4.2	1.0	89.4	4.0	1.0	91.5	4.2	1.0	92.4	2.5	1.0	0.0	0.0	NA	85.0	4.3	1.0
Missing Data	3.4	0.0	0.0	0.0	0.0	0.0	10.6	3.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.7	NA	6.3	1.5	0.3
Hypertension																								
Yes	73.4	6.0	3.0	59.0	4.5	1.0	64.4	4.8	1.7	67.3	4.8	1.3	73.6	5.3	1.2	54.1	3.2	2.5	45.2	0.0	0.0	63.1	4.7	1.3
No	24.9	2.0	1.0	41.0	4.6	1.0	34.0	2.9	1.0	32.7	3.6	1.0	26.4	4.4	1.0	45.9	1.3	1.0	54.8	1.3	1.0	36.3	3.6	1.0
Missing Data	1.7	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
Diabetes																								
Yes	28.8	8.2	2.2	24.9	6.9	1.8	29.6	4.1	1.0	31.0	6.7	1.9	29.5	4.0	0.7	20.9	2.8	1.3	25.3	0.0	0.0	27.1	5.9	1.6
No	68.7	3.7	1.0	75.1	3.8	1.0	69.3	4.1	1.0	68.1	3.5	1.0	70.5	5.5	1.0	79.1	2.2	1.0	74.7	0.9	1.0	72.2	3.7	1.0
Missing Data	2.5	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Chronic Obstructive Pulmonary Disease																								
Yes	11.0	13.9	3.5	26.4	4.2	0.9	8.8	7.5	2.0	10.0	2.9	0.7	20.2	5.8	1.2	14.0	0.0	0.0	9.6	0.0	0.0	17.5	5.2	1.3
No	85.6	4.0	1.0	73.6	4.7	1.0	80.3	3.8	1.0	88.5	4.3	1.0	79.8	4.9	1.0	86.1	2.7	1.0	90.4	0.8	1.0	79.5	4.1	1.0
Missing Data	3.4	0.0	0.0	0.0	0.0	0.0	10.9	3.0	0.8	1.5	20.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.2	0.8

N/A = indicates statistic not applicable/not meaningful

NOTE Percent distribution may not sum to 100 because of rounding

SOURCE Abstracts of clinical records among four demonstration hospitals, May-June, 1991 through December, 1993
Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993

TABLE 7-7

IN-HOSPITAL MORTALITY BY HEIGHT AND BODY MASS, ALL YEARS COMBINED

Characteristic	HOSPITAL A (N = 591)			HOSPITAL B (N = 1,735)			HOSPITAL C (N = 909)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio
Height (in meters)																								
Less than 1.65	34.7	4.4	1.3	24.2	7.6	3.3	24.5	3.6	0.9	29.5	8.0	2.0	19.4	6.0	1.0	30.2	3.9	NA	26.0	2.6	NA	26.2	5.8	1.9
1.65-1.74	34.4	6.4	1.8	29.6	5.3	2.3	32.8	4.7	1.1	33.0	1.8	0.5	31.8	4.9	0.8	34.3	3.4	NA	28.8	0.0	NA	31.5	4.7	1.5
1.75-1.84	24.4	3.5	1.0	37.1	2.3	1.0	34.1	4.2	1.0	29.2	4.0	1.0	37.6	6.2	1.0	27.9	0.0	NA	30.8	0.0	NA	33.4	3.1	1.0
1.85+	5.8	5.9	1.7	7.7	3.0	1.3	4.4	2.5	0.6	7.4	4.0	1.0	7.0	0.0	0.0	7.6	0.0	NA	4.1	0.0	NA	6.5	3.0	1.0
Missing Data	0.9	0.0	0.0	1.4	4.2	1.8	4.2	2.6	0.6	0.9	0.0	0.0	4.3	0.0	0.0	0.0	0.0	NA	10.3	0.0	NA	2.3	2.1	0.7
Body Mass Index																								
Less than 20	3.2	0.0	0.0	6.2	3.7	0.8	2.1	5.3	1.0	4.7	6.3	0.9	4.3	0.0	0.0	3.5	0.0	0.0	4.1	0.0	N/A	4.5	3.2	0.6
20 - 24	27.6	4.9	1.0	36.2	4.9	1.0	28.8	5.3	1.0	35.1	6.7	1.0	33.7	4.6	1.0	29.1	4.0	1.0	22.6	0.0	N/A	32.3	5.0	1.0
25 - 29	32.7	6.2	1.3	38.5	4.8	1.0	42.8	3.9	0.7	39.2	4.5	0.7	41.9	6.5	1.4	38.4	3.0	0.8	49.3	1.4	N/A	39.3	4.6	0.9
30 - 35	12.5	9.5	1.9	13.2	3.5	0.7	17.4	3.8	0.7	13.6	0.0	0.0	14.0	5.6	1.2	12.2	0.0	0.0	8.9	0.0	N/A	13.9	4.0	0.8
More than 35	4.1	0.0	0.0	4.4	4.0	0.8	4.7	0.0	0.0	6.5	0.0	0.0	1.9	0.0	0.0	5.2	0.0	0.0	4.8	0.0	N/A	4.5	1.6	0.3
Missing Data	20.0	1.7	0.3	1.5	3.9	0.8	4.2	2.6	0.5	0.9	0.0	0.0	4.3	0.0	0.0	11.6	0.0	0.0	10.3	0.0	N/A	5.6	1.7	0.3

N/A = Indicates statistic not applicable/not meaningful

NOTE: Percent distribution may not sum to 100 because of rounding

SOURCE: Abstracts of clinical records among four demonstration hospitals, May-June, 1991 through December, 1993
Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993

7.5.8 In-Hospital Mortality Stratified By Characteristics of CABG Surgery

Selected characteristics of the CABG operation were examined in relation to hospital mortality (Table 7-8). Interpretation of findings requires consideration of the strong relationships among the extent of anatomic coronary artery disease, severity of myocardial disease, the type and number bypass conduits, and the length of the operation. The number of conduits inserted ranged from 0 to more than 5 with a modal value of 3. Only modest differences in patterns were found among hospitals. Mortality was highest (7.7 percent) in the small proportion (1.3 percent) of patients who received no conduits. These patients were probably extremely ill and received only an atherectomy or angioplasty in an effort to reduce the duration of surgery. Among patients who received one or more conduits, there was an inverse relationship between mortality and the number of conduits. In-hospital mortality ranged from 3.3 percent in patients who received 5 or more conduits to 4.8 percent in those who received only 1 or 2 conduits. Possible explanations for these findings include decisions to limit the duration of surgery in relatively sick patients and a positive relationship between the more complete revascularization achieved with more conduits and in-hospital mortality.

Commonly used types of conduits include saphenous venous grafts (SVG) and optional grafts of internal mammary or gastro-eppiploic artery. Overall, 61.3 percent of patients received an arterial graft and 95.6 percent received one or more saphenous venous grafts. The proportion of patients who received an arterial graft ranged from 44 percent in Hospital D to 79.9 percent in Hospital A. This is a striking difference in view of the well-documented greater longevity of arterial grafts. The larger number of SVGs reflects the large modal number of conduits (3) and the limited number of available arterial grafts. The frequency of endarterectomy was less than 1 percent. The slightly higher mortality in patients who received a SVG (4.3 percent vs. 3.0 percent) may reflect more extensive coronary disease in these patients.

The revascularization index represents an attempt to estimate the extent of revascularization achieved to the extent of anatomic disease. The index was calculated by dividing the total number of conduits by the number of critical obstructions. An index of 1.0 indicates an equal number of obstructions and conduits or "complete revascularization." Mortality is slightly higher in patients with less than "complete" revascularization.

Perfusion time on the cardiopulmonary by-pass machine may be related to hospital mortality for at least two reasons. First, patients with more extensive disease need more conduits and will require longer procedures; second, longer periods of perfusion increase damage to red blood cells and the inherent risk of surgery. Data are missing for 5.8 percent of patients including 20.1 percent of those in Hospital A and 44.8 percent in Hospital F. Wide

TABLE 7-8

IN-HOSPITAL MORTALITY BY CHARACTERISTICS OF CABG SURGERY, ALL YEARS COMBINED

Characteristic	HOSPITAL A (N = 591)			HOSPITAL B (N = 1,735)			HOSPITAL C (N = 909)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio
Number of Conduits																								
0	4.6	3.7	0.5	0.9	18.8	3.5	0.4	0.0	0.0	0.0	0.0	N/A	0.4	0.0	0.0	1.2	0.0	0.0	1.4	0.0	N/A	1.3	7.7	1.6
1-2	26.1	7.8	1.0	19.6	5.3	1.0	21.6	3.6	1.0	31.9	2.8	1.0	23.6	8.2	1.0	39.5	1.5	1.0	26.0	0.0	N/A	23.3	4.8	1.0
3	39.1	4.8	0.6	38.0	3.9	0.7	45.0	3.9	1.1	49.3	6.0	2.1	36.1	6.5	0.8	38.4	4.6	3.1	38.4	0.0	N/A	40.6	4.3	0.9
4	25.7	2.6	0.3	30.4	4.5	0.8	26.3	5.1	1.4	16.5	3.6	1.3	33.7	2.3	0.3	18.0	0.0	0.0	28.0	2.4	N/A	27.7	4.0	0.8
5+	4.6	3.7	0.5	11.1	4.2	0.8	4.6	2.4	0.7	2.4	0.0	0.0	6.2	0.0	0.0	2.9	0.0	0.0	6.2	0.0	N/A	7.2	3.3	0.7
Type of Conduit																								
IMA/GEPA	79.9	4.2	1.0	55.8	3.1	1.0	61.4	2.3	1.0	44.0	2.0	1.0	78.3	4.0	1.0	56.4	2.1	1.0	67.8	0.0	N/A	61.3	3.0	1.0
IMA/GEPA ONLY	5.4	0.0	0.0	2.6	4.4	1.4	2.6	0.0	0.0	3.8	0.0	0.0	2.7	28.6	7.2	4.7	12.5	6.0	1.4	0.0	N/A	3.2	3.8	1.3
SVG	90.0	5.3	1.3	96.5	4.4	1.4	96.9	4.2	1.8	96.2	4.6	2.3	96.9	4.1	1.1	94.2	1.9	0.9	97.3	0.7	N/A	95.6	4.3	1.4
SVG ONLY	15.6	8.7	2.1	43.3	6.1	2.0	38.2	6.9	3.0	56.1	6.3	3.2	21.3	9.1	2.3	42.4	2.7	1.3	30.8	2.2	N/A	37.4	6.3	2.1
Revascularization Index*																								
Less than 1.0	26.9	6.3	1.4	20.4	4.5	1.0	14.6	3.8	0.9	24.8	3.6	0.8	41.1	4.7	0.9	33.1	3.5	2.1	28.8	2.4	N/A	22.5	4.5	1.1
1.0 +	73.1	4.4	1.0	79.6	4.6	1.0	85.4	4.1	1.0	75.2	4.7	1.0	58.9	5.3	1.0	66.9	1.7	1.0	71.2	0.0	N/A	77.5	4.2	1.0
Perfusion Time																								
(minutes)																								
60 or less	11.5	2.9	1.0	32.5	2.3	1.0	15.1	1.5	1.0	4.1	0.0	N/A	46.9	3.3	1.0	54.7	3.2	1.0	8.9	0.0	N/A	24.3	2.4	1.0
61-100	46.4	4.4	1.5	49.3	3.3	1.4	58.4	3.2	2.1	22.7	2.6	N/A	36.1	1.1	0.3	0.6	0.0	0.0	49.3	1.4	N/A	45.9	3.2	1.3
101+	22.0	10.0	3.4	17.2	12.4	5.4	25.0	7.6	5.0	72.6	5.3	N/A	13.6	22.9	6.9	0.0	0.0	0.0	39.7	0.0	N/A	23.9	8.8	3.7
Missing Data	20.1	1.7	0.6	1.0	5.9	2.6	1.5	7.1	4.7	0.6	0.0	N/A	3.5	0.0	0.0	44.8	1.3	0.4	2.1	0.0	N/A	5.8	2.1	0.9

IMA/GEPA = internal mammary artery/gastro-epiploid artery

* Revascularization Index equals number of conduits / number of obstructions

N/A = indicates mortality rate not applicable/not meaningful

NOTE Percent distribution may not sum to 100 because of rounding.

SOURCE Abstracts of clinical records among four demonstration hospitals, May-June, 1991 through December, 1992
Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993

variations are in the proportions of patients who had perfusion times in excess of 100 minutes, ranging from no patients in Hospital F to 72.6 percent in Hospital D. Mortality was nearly 3.7 times higher in patients with perfusion times in excess of 100 minutes compared to those with perfusion times of 60 minutes or less (8.8 percent vs. 2.4 percent).

7.5.9 In-Hospital Mortality Stratified By Post-Operative Complications

Reoperations after CABG surgery may be required for bleeding, graft occlusion, or other reasons. The frequency of reoperations and their associations with in-hospital mortality are shown in Table 7-9. Overall, 5.7 percent of patients underwent a second procedure during the same admission. Data on the reasons for reoperations were missing in nearly 44 percent of patients, but bleeding was the cause in two-thirds of patients for whom data were available. Reoperations were performed in only 1.2 percent of patients in Hospital F to 10.1 percent of patients in Hospital E. The reoperation rate fell by nearly 23-42 percent in 3 of the 4 initial demonstration sites between 1992 and 1993; the exception was Hospital D. The need for reoperation was strongly related to in-hospital mortality (13.5 percent vs. 3.3 percent; odds ratio 4.1).

The frequencies of other types of complications and their associations with in-hospital mortality are shown in Table 7-10. Comparisons among hospitals need to be interpreted with caution because of differences both in the definitions used for classifying complications (e.g., wound infection or neurologic event) and differences in the completeness of documentation.

One or more complications was reported in 35.3 percent of patients overall and ranged from 13.7 percent in Hospital G to 57.5 percent in Hospital C and 59.9 percent in Hospital F. The most common types of complications were pulmonary, seen in 10.1 percent of patients, and neurologic events such as strokes or altered consciousness, seen in 7.9 percent. Wound infections were reported in 4.2 percent of patients, renal failure requiring dialysis in 2.6 percent, and vascular complications such as arterial emboli and ilio-femoral or aortic dissection in 0.8 percent. The occurrence of complications was consistently and strongly associated with increased in-hospital mortality. Odds ratios were 19.2 for renal failure, 12.3 for vascular complications, 6.0 for neurologic events, 5.5 for pulmonary complications, and 3.3 for wound infections.

7.5.10 Hospital Length of Stay

Bundled payments create powerful incentives to reduce lengths of stay and other costs. Tables 7-11 and 7-12 show time trends in CABG lengths of stay for DRG 106 and 107,

TABLE 7-9

IN-HOSPITAL MORTALITY BY REOPERATION, ALL YEARS COMBINED

Characteristic	HOSPITAL A (N = 591)			HOSPITAL B (N = 1,735)			HOSPITAL C (N = 909)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Reta (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio
Reoperation																								
Reop for CABG in 1991																						6.8	15.1	5.8
Yes	11.1	13.3	2.3	6.9	17.9	8.5	2.3	25.0	10.4	8.2	0.0	N/A										93.0	2.6	1.0
No	88.9	5.8	1.0	92.8	2.1	1.0	97.7	2.4	1.0	90.4	0.0	N/A										0.3	100.0	38.5
Missing Data	0.0	N/A	N/A	0.3	100.0	47.6	0.0	N/A	N/A	1.4	100.0	N/A												
Reop for CABG in 1992																						6.3	14.6	4.7
Yes	9.3	5.3	1.0	4.8	16.1	5.0	6.4	19.1	8.3	9.0	18.2	18.2										92.0	3.1	1.0
No	90.2	5.4	1.0	94.1	3.2	1.0	93.6	2.3	1.0	60.3	1.0	1.0										1.6	47.6	15.4
Missing Data	0.5	100.0	18.5	1.1	57.1	17.8	0.0	N/A	N/A	10.7	38.5	38.5												
Reop for CABG in 1993																								
Yes	6.8	0.0	0.0	2.8	26.3	5.7	4.9	13.3	3.7	9.2	30.8	38.5	10.1	7.7	1.6	1.2	0.0	0.0	3.4	0.0	N/A	4.9	11.8	3.2
No	74.6	1.6	1.0	97.1	4.6	1.0	94.9	3.6	1.0	88.7	0.8	1.0	89.9	4.7	1.0	98.8	2.4	1.0	86.3	N/A	N/A	91.8	3.7	1.0
Missing Data	18.7	10.6	6.6	0.1	100.0	21.7	0.1	0.0	0.0	2.1	33.3	41.6	0.0	N/A	N/A	0.0	N/A	N/A	10.3	6.7	N/A	3.2	11.9	3.2
Overall Reop																								
Yes	8.6	5.9	1.4	4.5	19.2	5.5	5.0	13.3	3.7	8.9	20.0	28.6	10.1	7.7	1.6	1.2	0.0	0.0	3.4	0.0	N/A	5.7	13.5	4.1
No	83.3	4.1	1.0	95.0	3.5	1.0	94.9	3.6	1.0	86.1	0.7	1.0	89.9	4.7	1.0	98.8	2.4	1.0	86.3	N/A	N/A	92.1	3.3	1.0
Missing Data	8.1	12.5	3.0	0.5	67.7	19.3	0.1	0.0	0.0	5.0	41.2	58.9	0.0	N/A	N/A	0.0	N/A	N/A	10.3	6.7	N/A	2.2	22.2	6.7

Note Reoperation here refers to having to operate again following an initial CABG surgery during the same admission, it does not mean that the initial CABG surgery was the patient's second

SOURCE Abstracts of clinical records among four demonstration hospitals, May-June, 1991 through December, 1993
Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993

TABLE 7-10

IN-HOSPITAL MORTALITY BY POST-OPERATIVE COMPLICATIONS, ALL YEARS COMBINED

Characteristic	HOSPITAL A (N = 591)			HOSPITAL B (N = 1,735)			HOSPITAL C (N = 969)			HOSPITAL D (N = 339)			HOSPITAL E (N = 258)			HOSPITAL F (N = 172)			HOSPITAL G (N = 146)			TOTAL (N = 4,150)		
	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio	Proportion (%)	Mortality Rate (%)	Risk Ratio
Complications																								
Any Complications																								
Yes	30.9	16.2	N/A	27.3	16.5	165.0	57.5	7.1	N/A	31.6	14.0	N/A	21.7	23.2	N/A	59.9	3.9	N/A	13.7	5.0	N/A	35.3	12.1	N/A
No	67.1	0.0	N/A	72.8	0.1	1.0	42.5	0.0	N/A	67.5	0.0	N/A	78.3	0.0	N/A	40.1	0.0	N/A	86.3	0.0	N/A	64.4	0.0	N/A
Missing Data	2.0	0.0	N/A	0.0	N/A	N/A	0.0	N/A	N/A	0.9	0.0	N/A	0.0	N/A	N/A	0.0	N/A	N/A	0.0	N/A	N/A	0.4	0.0	N/A
Infection																								
Yes	7.1	9.5	2.7	4.9	22.4	6.2	2.5	4.4	1.1	4.7	6.3	3.3	3.9	0.0	0.0	0.0	N/A	N/A	0.0	N/A	N/A	4.2	14.2	3.3
No	86.1	3.5	1.0	95.1	3.6	1.0	97.5	4.1	1.0	91.2	1.9	1.0	96.1	5.2	1.0	100.0	2.3	1.0	100.0	0.7	1.0	94.5	4.3	1.0
Missing Data	6.8	17.5	5.0	0.0	N/A	N/A	0.0	N/A	N/A	4.1	57.1	30.1	0.0	N/A	N/A	0.0	N/A	N/A	0.0	N/A	N/A	1.3	16.7	3.9
Neurologic																								
Yes	3.1	22.2	6.3	6.5	22.3	6.8	8.4	10.5	3.0	6.8	4.3	1.8	1.2	33.3	7.1	51.2	2.3	1.0	6.2	0.0	0.0	7.9	12.5	6.0
No	90.5	3.5	1.0	93.5	3.3	1.0	91.1	3.5	1.0	87.3	2.4	1.0	98.8	4.7	1.0	48.8	2.4	1.0	93.8	0.7	1.0	90.7	2.1	1.0
Missing Data	6.4	15.8	4.5	0.0	N/A	N/A	0.0	N/A	N/A	5.6	36.8	15.3	0.0	N/A	N/A	0.0	N/A	N/A	0.0	N/A	N/A	1.4	15.8	7.5
Pulmonary																								
Yes	7.8	6.5	1.6	12.1	10.5	2.8	11.9	13.9	5.0	9.7	9.1	5.4	0.0	N/A	N/A	2.3	0.0	0.0	13.7	5.0	N/A	10.1	10.5	5.5
No	85.1	4.0	1.0	88.0	3.7	1.0	88.1	2.8	1.0	85.8	1.7	1.0	100.0	5.0	1.2	97.7	2.4	1.0	86.3	0.0	N/A	88.5	1.9	1.0
Missing Data	7.1	14.3	3.6	0.0	N/A	N/A	0.0	N/A	N/A	4.4	46.7	27.5	0.0	N/A	N/A	0.0	N/A	N/A	0.0	N/A	N/A	1.4	21.5	11.3
Renal																								
Yes	1.5	44.4	12.7	1.4	40.0	10.0	7.4	26.9	11.7	1.8	50.0	31.3	0.0	N/A	N/A	0.0	N/A	N/A	0.0	N/A	N/A	2.6	32.7	19.2
No	91.7	3.5	1.0	98.6	4.0	1.0	92.6	2.3	1.0	92.9	1.6	1.0	100.0	5.0	1.0	100.0	2.3	1.0	100.0	0.7	1.0	96.0	1.7	1.0
Missing Data	6.7	15.0	4.3	0.0	N/A	N/A	0.0	N/A	N/A	5.3	38.9	24.3	0.0	N/A	N/A	0.0	N/A	N/A	0.0	N/A	N/A	1.4	16.0	9.4
Vascular																								
Yes	1.2	14.3	3.5	0.0	N/A	N/A	1.3	33.3	9.0	1.5	40.0	30.8	1.9	20.0	4.3	0.6	0.0	0.0	0.7	0.0	0.0	0.8	25.8	12.3
No	91.9	4.1	1.0	100.0	4.6	1.0	98.7	3.7	1.0	92.3	1.3	1.0	98.1	4.7	1.0	99.4	2.3	1.0	99.3	0.7	1.0	98.4	2.1	1.0
Missing Data	6.9	14.6	3.6	0.0	N/A	N/A	0.0	N/A	N/A	6.2	42.9	33.0	0.0	N/A	N/A	0.0	N/A	N/A	0.0	N/A	N/A	1.5	17.4	8.3
Other																								
Yes	6.1	63.9	58.1	10.0	24.1	10.0	7.9	27.2	13.6	15.0	15.7	6.5	12.0	16.1	4.6	5.8	20.0	16.7	2.1	0.0	0.0	9.1	26.5	12.6
No	93.9	1.1	1.0	90.0	2.4	1.0	92.1	2.0	1.0	85.0	2.4	1.0	88.0	3.5	1.0	94.2	1.2	1.0	98.0	0.7	1.0	90.9	2.1	1.0

N/A = indicates not applicable/not meaningful

NOTE Percent distribution may not sum to 100 because of rounding.

SOURCE Abstracts of clinical records among four demonstration hospitals, May-June, 1991 through December, 1993.
Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993.

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TABLE 7-11

LENGTH OF STAY FOR DRG 106, BY HOSPITAL AND PERIOD

	May 1991 - Dec. 1991		Jan. 1992 - June 1992		July 1992 - Dec. 1992		Jan. 1993 - June 1993		July 1993 - Dec. 1993	
	Mean (Days)	Standard Error (Days)	Mean (Days)	Standard Error (Days)	Mean (Days)	Standard Error (Days)	Mean (Days)	Standard Error (Days)	Mean (Days)	Standard Error (Days)
Hospital A										
Total LOS	14.15	0.86	15.78	1.21	14.11	1.07	13.57	1.29	12.86	0.73
Pre-op	5.26	0.43	5.75	0.65	4.51	0.52	5.05	0.86	5.38	0.70
Post-op	8.89	0.72	10.03	1.06	9.60	0.83	8.51	1.03	7.48	0.63
Hospital B										
Total LOS	11.45	0.68	11.80	0.76	11.02	0.72	9.34	0.42	8.88	0.41
Pre-op	2.72	0.23	2.84	0.31	2.63	0.37	2.61	0.22	2.04	0.19
Post-op	8.72	0.63	8.96	0.63	8.38	0.60	6.73	0.30	6.83	0.36
Hospital C										
Total LOS	12.48	0.43	11.69	0.49	11.57	0.56	11.28	0.38	11.86	0.43
Pre-op	3.66	0.30	3.31	0.25	3.81	0.38	3.65	0.26	3.74	0.26
Post-op	8.82	0.34	8.38	0.43	7.76	0.33	7.64	0.28	8.12	0.33
Hospital D										
Total LOS	17.95	1.40	13.14	0.73	16.59	1.31	14.70	1.00	14.46	1.06
Pre-op	5.89	0.53	4.97	0.43	5.22	0.55	4.85	0.49	6.11	0.72
Post-op	12.07	1.27	8.17	0.65	11.38	1.16	9.85	0.87	8.35	0.74
Hospital E										
Total LOS							11.83	1.41	11.08	0.51
Pre-op							2.39	0.51	2.32	0.20
Post-op							9.44	1.42	8.76	0.45
Hospital F										
Total LOS							9.00	.68	10.48	.48
Pre-op							1.73	.43	2.68	.22
Post-op							7.3	.52	7.80	.43
Hospital G										
Total LOS							9.47	1.19	10.83	0.74
Pre-op							2.37	0.47	3.22	0.35
Post-op							7.11	1.14	7.61	0.59

NOTE: Reported pre-op and post-op lengths of stay may not sum to the reported total length of stay. Total length of stay was defined as discharge date minus admission date, post-op as discharge date minus CABG surgery date. Total length of stay, however was defined as one day if admission and discharge occurred on the same day, while per- and post-op lengths of stay were permitted to equal 0.

SOURCE: Abstracts of clinical records among four demonstration hospitals, May-June, 1991 through December, 1993. Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993.

hearttables\TAB7-11.XLS\nd

TABLE 7-12

LENGTH OF STAY FOR DRG 107, BY HOSPITAL AND PERIOD

	May 1991 - Dec. 1991		Jan. 1992 - June 1992		July 1992 - Dec. 1992		Jan. 1993 - June 1993		July 1993 - Dec. 1993	
	Mean (Days)	Standard Error (Days)	Mean (Days)	Standard Error (Days)	Mean (Days)	Standard Error (Days)	Mean (Days)	Standard Error (Days)	Mean (Days)	Standard Error (Days)
Hospital A										
Total LOS	10.72	0.73	9.14	0.42	9.97	0.62	8.59	0.31	8.69	0.37
Pre-op	1.44	0.18	1.29	0.12	1.60	0.19	1.52	0.18	1.71	0.17
Post-op	9.28	0.67	7.85	0.40	8.36	0.56	7.07	0.26	6.97	0.35
Hospital B										
Total LOS	9.29	0.28	8.89	0.43	8.95	0.42	8.09	0.30	7.64	0.41
Pre-op	1.15	0.06	0.94	0.07	1.16	0.11	1.00	0.08	0.98	0.08
Post-op	8.14	0.27	7.94	0.43	7.77	0.39	7.09	0.28	6.65	0.40
Hospital C										
Total LOS	9.59	0.42	9.64	0.40	9.35	0.58	9.04	0.38	8.23	0.37
Pre-op	1.30	0.08	1.68	0.19	1.74	0.27	1.25	0.14	1.31	0.20
Post-op	8.29	0.41	7.96	0.32	7.60	0.40	7.79	0.34	6.89	0.28
Hospital D										
Total LOS	14.20	1.75	15.57	2.21	10.66	0.96	11.57	1.05	12.10	2.22
Pre-op	2.20	0.44	2.71	0.98	1.52	0.32	1.89	0.38	1.60	0.39
Post-op	12.00	1.72	12.86	2.18	9.14	0.93	9.68	1.02	10.50	2.26
Hospital E										
Total LOS							10.52	0.87	10.70	0.47
Pre-op							1.07	0.26	0.87	0.08
Post-op							9.44	0.88	9.82	0.44
Hospital F										
Total LOS							7.85	0.42	8.37	0.32
Pre-op							1.54	0.29	1.43	0.17
Post-op							6.31	0.26	6.94	0.33
Hospital G										
Total LOS							6.81	0.51	8.41	0.60
Pre-op							0.86	0.20	1.02	0.28
Post-op							5.95	0.42	7.39	0.51

NOTE: Reported pre-op and post-op lengths of stay may not sum to the reported total length of stay. Total length of stay was defined as discharge date minus admission date, post-op as discharge date minus CABG surgery date. Total length of stay, however was defined as one day if admission and discharge occurred on the same day, while per- and post-op lengths of stay were permitted to equal 0.

SOURCE: Abstracts of clinical records among four demonstration hospitals, May-June, 1991 through December, 1993. Hospitals E, F and G entered the demonstration two years later than the original four hospitals, in May, 1993.

respectively. Analyses are performed for total, pre-operative, and post-operative lengths of stay as defined in section 7.2.

For DRG 106 (coronary angiogram and CABG surgery on the same admission) , the mean total length of stay in the first four demonstration sites during May-December 1991 ranged from 11.5 days in Hospital B to almost 18 days in Hospital D. By July-December 1993, corresponding mean lengths of stay had fallen to 8.9 days and 14.5 days. All four hospitals reduced their lengths of stay by amounts ranging from 0.6 days to 3.5 days. In three of the four hospitals, almost all of the reduction in length of stay occurred during the post-operative period. Only Hospital B reduced pre-operative length of stay by an appreciable amount (0.7 days). It is interesting that this same hospital also had the lowest pre-operative length of stay in 1991 (2.7 days). The three new sites had total, pre-operative, and post-operative lengths of stay that were shorter than three of the four original sites during July-December 1993.

For DRG 107 (CABG surgery only during the admission), mean total length of stay in the four original sites ranged from 9.3 days to 14.2 days in May-December 1991, and from 7.6 to 12.1 days in July-December 1993 reflecting decreases of from 1.4 days to 2.1 days. The same two hospitals represented the extremes for DRG 107 as they did for DRG 106. Only Hospital D reduced its pre-operative LOS by an appreciable amount (0.6 days from 2.2 to 1.6 days). Total, pre-operative, and post-operative LOS for the new sites were again in the mid-range for the original sites.

7.5.11 Post-Discharge Mortality

Mortality rates at intervals from 1 to 12 months after CABG surgery are presented in Table 7-13. Results are limited to the original sites because only their patients have had the opportunity for 12 months of follow-up. As the evaluation continues, data for the new sites plus more recent discharges from the original sites will become available and possibly change the results.

A regrettable limitation of the post-discharge evaluation of outcomes is the lack of information on non-cardiac-related causes of death. Nevertheless, the sample sizes are relatively large, and one might assume that random, unrelated, causes of death would cancel out across sites. In the multivariate work presented in 7.6 below, we further control for patient demographic and clinical characteristics that may be risks for adverse post-discharge outcomes. It is our intention to collect cause-of-death information in subsequent analyses.

TABLE 7-13

CUMULATIVE MORTALITY RATES DURING FIRST YEAR FOLLOWING CABG SURGERY BY HOSPITAL FOR PATIENTS UNDERGOING CABG SURGERY THROUGH DECEMBER 1992

	Time Following CABG Surgery					Number of Records Missing Either Date of Death or Date of CABG
	1 Month %	3 Months %	6 Months %	9 Months %	One Year %	
Hospital A (N=339)	6.78	7.37	8.85	10.03	10.91	4
Hospital B (N=1044)	3.83	4.31	5.27	5.65	6.90	13
Hospital C (N=498)	2.61	3.01	3.41	4.42	4.82	4
Hospital D (N=195)	3.59	3.59	3.59	4.62	5.13	15
Total (N=2076)	4.00	4.43	5.25	5.97	6.89	36

NOTE: The cohort represented above excludes all CABG patients operated on after December 1992, as one-year mortality data were unavailable for later patients.

SOURCE: Tabulated from (1) medical records and physician clinical abstracts provided by participating hospitals, and (2) from the Medicare Enrollment files, 1991, 1992 and 1993.

Overall, unadjusted mortality increased 73 percent from 4.0 percent at one month to 6.9 percent at one year.[1] Unadjusted one-month mortality ranged from 2.6 percent in Hospital C to 6.8 percent in Hospital A. One-year follow-up mortality ranged from 4.8 percent to 10.9 percent in the same two extreme hospitals.

7.5.12 Readmissions During the First Post-Operative Year

Table 7-14 reports data from the one-year follow-up survey on hospital readmissions, anginal status and medications. The number of CABG patients for whom follow-up data are available is less than the total demonstration sample of 4,150 because one-year follow-up information are currently available only for patients undergoing CABG surgery through December 1992, and also because not even all of these patients were followed-up. Data are reported for the four original sites only, as the newer sites, not joining the demonstration until 1993, have not submitted one-year follow-up information. In total, 1,286 patient follow-up records are available. Note that the readmission rates in Table 7-14 are defined as the number of patients who had at least one readmission; no consideration is given to multiple readmissions for the same patient. The readmission need not have been to the same hospital at which the surgery was performed.

According to the survey results, the overall readmission rate among reported cases was 28.6 percent. Institutional readmission rates at Hospitals A, C, and D were fairly similar (36.8 percent, 38.1 percent, and 42.3 percent, respectively), but the rate for Hospital B was reported as a particularly low 10.5 percent. Claims data analysis of average 90-day readmission rates, performed for the costing section of the evaluation, establish that this reported one-year readmission rate at Hospital B must be incorrect. Averaging over all 1991 and 1992 demonstration patients, the 90-day post-discharge readmission rate at Hospital B is 25 percent. As noted in the data sources section, follow-up data from Hospital B were received by the evaluation team in an especially complicated format, and were in general deemed to be the least reliable set of one-year data. And given the claims finding, this anomalous rate of readmission should be disregarded. For no other site did the one-year follow-up survey readmission rates appear to conflict with their 90-day claims-based counterparts: Hospital A had 31 percent of patients readmitted within 90 days, Hospital C, 20 percent, and D, 29 percent. Each of these rates is lower than the estimated one-year rate in Table 7-14.

[1] The one-month mortality rate is slightly lower than the inpatient rate reported in Table 7-5-2 which reported on all seven hospitals and included 1993 patients.

TABLE 7-14

HOSPITAL READMISSION, ANGINAL STATUS AND ANGINA MEDICATIONS AT ONE YEAR FOLLOWING CABG SURGERY

Hospital Readmission	Hospital A (N=210)	Hospital B (N=465)	Hospital C (N=426)	Hospital D (N=185)	Total* (N=1286)
Readmission Within One Year	36.8 %	10.5 %	38.1 %	42.3 %	28.6 %
N Missing	*9*	*0*	*11*	*10*	*30*
Angina Recurrence One Year Following Surgery					
Reported Angina	2.5 %	12.5 %	N/A	13.5 %	9.8 %
N Missing	*10*	*0*	*N/A*	*29*	*39*
Patient taking at least one Angina Medicat	56.7	43.7	45.8	48.7	47.2
Either reported Angina or one Medication	56.7	49.3	45.8	50.3	49.5
Medications Prescribed One Year After CABG Surgery					
Beta Blockers	50.0	22.8	16.7	38.9	27.5
Calcium Antagonists	11.4	24.7	23.9	13.0	20.6
Nitrates	4.3	4.1	12.0	9.2	7.5

NOTE: No missing data figures are reported for medications; data are from a collection form in which one is asked to "circle all that apply" with regard to medications being taken at one year following surgery.

* Hospital C reported no data on angina recurrence. The total percentage with reported angina, therefore, is calculated without Hospital C's patients included; the actual sample size where reported angina is concerned is N=821.

SOURCE: One-year follow-up surveys conducted by the original four demonstration sites.

heart\tables\TAB7-14.XLS\nd

7.5.13 Angina Relief During the First Post-Operative Year

Table 7-14 also reports three different estimates of angina recurrence based on different definitions. The first was the response on the follow-up form to the question of whether the patient was suffering angina. Because of the possibility that this might not be well-reported due to definitional issues or human error and also because Hospital C reported no angina data, a second estimate of angina recurrence was constructed, based on whether the patient was using any anti-anginal drugs (nitrates, beta-blockers or calcium antagonists) at the time of the follow-up. The overall rate of reported angina recurrence was 9.8 percent (note that this rate excludes Hospital C's patients). The figure varied from only 2.5 percent at Hospital A to 13.5 percent at Hospital B. Comparing these figures to the proportion of patients taking at least one anti-anginal drug one year following surgery, we see that the reported angina figures appear to underestimate the prevalence of post-discharge angina among demonstration patients. Overall, 47.2 percent of followed-up patients were reported to be on anti-anginal drugs.

The medication-based estimate of angina recurrence was far greater at each site than the reported rate. Hospital A, the site with the lowest reported rate of angina recurrence (2.5 percent), was also the site with the highest rate of medication use (56.7 percent). Table 7-14 also reports that 49.5 of patients overall either were reported to have angina or were on medications.

7.6 Multivariate Analysis

7.6.1 Rationale

Bivariate analysis of mortality rates by hospital or risk factor, while useful, can often result in misleading conclusions, especially when many of the risk factors are highly correlated and occur in different hospitals with varying frequency. For example, patients with low ejection fractions may be more likely to be experiencing a heart attack upon admission; if the heart attack is the key risk factor for survival, rather than the low ejection fraction, simple comparisons of patients by ejection fraction will overstate the importance of this factor in patient mortality. Similarly, differences in hospital death rates might be due more to differing combinations of risk factors, in which case bivariate comparisons using a single risk factor will be misleading. Absent a rigorous randomized trial, multivariate statistical analysis is needed in order to properly assess the mortality effects of each patient characteristic, controlling for all others.

7.6.2 Methods

7.6.2.1 Model

The standard method for modeling a binary outcome such as mortality is logistic regression. Linear least squares, in which a dichotomous outcome (here, survival or death coded as 0 or 1) is regressed directly on a set of explanatory variables, produces biased and inefficient coefficient estimates. Probit estimation, a common alternative to logistic regression, produces efficient and unbiased estimates, but its parameter coefficients lack a convenient, straightforward marginal interpretation. Logistic regression, efficient and unbiased, produces an odds ratio for every regressor, thus providing simple estimates of each regressor's effect on the dependent variable.

The logistic model is used in this study to evaluate differences in the risk of mortality attributable to differences across hospitals, patient risk factors, and time. The model is specified as:

$$P_i = 1 / (1 + e^{-\beta X}) \qquad (1)$$

where P_i = the probability that the i-th individual will die during a given admission, and βX_i = an index value for the i-th individual based on his or her specific set of characteristics (represented by the X_i vector), and e = the base of natural logarithms.

Unlike least squares regression, the coefficients from logistic regression are not directly interpretable. Fortunately, a convenient and powerful interpretation of the coefficients is found in the odds ratio. Assume we are interested in assessing the effects of the presence or absence of congestive heart failure (CHF) on in-hospital mortality. In this hypothetical model, y is a (0,1) variable indicating mortality (1 if the patient died in the hospital), and x is a (0,1) variable indicating the presence of congestive heart failure (x=1 if CHF is present). The odds of in-hospital death occurring among those with CHF (x=1) is defined as $\pi(1)/[1-\pi(1)]$, where $\pi(1)$ is the probability of death given the presence of CHF. Similarly, the odds of death among those not suffering from CHF is defined as $\pi(0)/[1-\pi(0)]$, where $\pi(0)$ is the probability of death given the absence of CHF. The odds ratio, denoted by Ψ, is defined as the ratio of the odds of death for x=1 to the odds for x=0, and is represented by the equation

$$\psi = \frac{\pi(1)/[1-\pi(1)]}{\pi(0)/[1-\pi(0)]} = e^{\beta_{CHF}} \qquad (2)$$

where β_{CHF} is simply the coefficient of the congestive heart failure variable in the logistic regression. The power of the odds ratio is that it approximates relative risk, or how much more likely in-hospital death is, given the presence of CHF; an odds ratio of 1.35, for example, indicates that a CABG patient with CHF is thirty-five percent more likely to die than a patient without CHF, while an odds ratio of .50 indicates he is half as likely to die. Relative risk is defined as the ratio $\pi(1)/\pi(0)$. Ψ is therefore a good estimate of relative risk when $\pi(x)$ is small for both x=0 and x=1, as in the case of our mortality model. Note that an odds ratio must be greater than zero; variables having a negative effect on the outcome variable will have an odds ratio between 0 and 1.

Interpretation of the marginal effects of dichotomous variables is thus very straightforward. The interpretation of continuous variables is only slightly more complicated, as the odds ratio is dependent on the scale of the continuous variable. The odds ratio reported by logistic regression for a continuous variable reports the change in the likelihood of mortality given an increase of "1" unit in x. For example, the logistic mortality analysis uses patient ejection fraction, ranging from 1 to 100, as a risk factor. However, a change of only 1 unit in ejection fraction might be of little clinical interest; physicians may prefer to think in terms of 5 or 10 units. Fortunately, the odds ratio is easily scaled to accommodate these alternative interpretations by multiplying the coefficient by the meaningful difference then exponentiating.

Consider as an example a logistic regression in which the dependent variable is death, and the independent variable is ejection fraction, measured from 1 to 100. A coefficient estimate of -0.02 yields an odds ratio of .98, and the interpretation would be that an ejection fraction value that is one percentage-point higher is associated with a risk of mortality only 98 percent of that associated with the lower ejection fraction. To estimate the relative risk of a twenty percentage-point increase in ejection fraction, simply multiply the coefficient by twenty, and exponentiate: exp(-0.02x20) = .67. The new interpretation, that an ejection fraction twenty percentage points higher reduces risk by 33 percent, may be of much greater interpretive value.

All logistic regression results reported here include odds ratios and P-values. Most of the independent variables analyzed are binary variables, but some are continuous; any odds ratios that have been scaled are noted appropriately.

7.6.2.2 Equation Specification

Logistic regression was performed using two different dependent variables: in-hospital mortality and mortality within one year following CABG surgery. The general specification of the logistic model was as follows:

$$P[O_{ih} = 1|X_{ih}] = f[H_{ih}; TIME_{ih}; RF_{ih}; C_{ih}] \quad (3)$$

where the dependent variable is the probability, P, of an outcome O_{ih}= 1 if death occurred for the i-th patient at hospital h given the set, X_{ih}, of patient and hospital characteristics. For purposes of this evaluation, the relevant set of independent variables include a vector of dummy variables for demonstration hospital (H_{ih}), a trend variable indicating the month during which the CABG surgery occurred ($TIME_{ih}$, coded as 1 for the first month of the demonstration in May 1991, 2 for the second, through 32), a vector of risk factors associated with the i-th patient in hospital h (RF_{ih}), and a vector of post-operative complications (C_{ih}). Because complications may have been the result of poor quality care, models are estimated with and without their inclusion.

The focus of the logistic analysis is on the original four demonstration sites. The other three sites did not enter the demonstration until mid-1993, and entering them into the model poses problems regarding interpretation of the trend coefficient. While discussion of inpatient logistic mortality will center on the four-site regressions, a similarly-specified logistic regression using all sites (except Hospital F, which was excluded because its particularly low mortality rate caused convergence problems) is reported in Appendix 7. An all-sites regression for one-year mortality was not possible, as one-year follow-up data were not available for 1993 patients.

7.6.2.3 Pooled Inpatient Mortality Models

Four pooled models were estimated with inpatient mortality as the dependent variable. The first of these simply included dummy variables representing three of the initial four sites. Hospital C, having the lowest inpatient mortality rate among the old sites, was chosen to be the hospital of comparison, and its mortality rate is represented by the intercept. The hospital coefficient estimates in this first regression thus reflect differences between the three other original hospitals and Hospital C before controlling for any patient risk factors. These hospital dummy coefficients form a baseline upon which to compare the effects of controlling for time trends and patient risk factors. If none of the hospital coefficients change as the other variables are stepped into the regression, we can conclude that patient mix is uncorrelated with site of surgery among these institutions.

The second model includes the hospital dummies and the time trend variable. Inclusion of the trend variable in this stage tests whether outcomes across all sites differ systematically *as a group* between the early months of the demonstration and the later months.

Again, this regression controls for no patient risk factors. An insignificant time trend here would imply that there was no discernible improvement or decline in inpatient mortality prior to controlling for differences in patient severity. This is an important finding in its own right for two reasons. First, this one coefficient represents the overall time effect of bundled payments on inpatient mortality across all participating hospitals, and an insignificant finding suggests that such payments have no mortality effect in the aggregate. Because no rigorous control group is available, we cannot say what the mortality trend might have been in lieu of the demonstration. Second, if the time trend coefficient changes substantially when risk factors are stepped into the regression, we will have a benchmark with which to compare the importance of risk factors over time.

The third model included the hospital dummies, the trend variable, and an extensive list of patient risk factors. This full inpatient mortality model, represented in Equation 3, controls for all pre-operative patient risk factors thought to be important to the risks of in-hospital mortality. A fourth model was generated using the strongest variables from the third model; namely those variables with p-values of .2 or less were selected for forward stepwise entry into this model, with the entry criterion that a variable have a p-value of .1 or better in this new model. The result is a "deleted" model which should report coefficients and odds ratios closely representing the "true" effects of the risk factors. Risk factor coefficients are, of course, of interest in their own right. Clinicians are interested in those correlates most likely to predict an adverse outcome, especially death. Because this is not a randomized trial, however, we can never conclude that the coefficient on a particular risk factor is unbiased. It is possible that some unmeasured variable, either among patients or in the care they received, increased or decreased the importance of an *ex ante* risk characteristic.

There is also the possibility of randomly biased results. With approximately 3,000 patients in the regression sample over thirty-two months, this threat would appear to be small.[2] However, many patients were excluded from the regression analysis because their records were missing key pieces of data, such as ejection fraction. There is always the possibility that the pool of records with missing data is not random.

Since time trends might differ across the participating hospitals, hospital-specific models were also run, using the set of independent variables appearing in Model 4. The advantage of separate estimation is that hospitals are tested for trends in mortality "only among themselves"; this approach avoids cross-facility data definition problems, and picks up differences in outcome trends across hospitals that the pooled model does not. The disadvantage is a loss in statistical power resulting from the smaller sample sizes.

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[2] Hospital-specific regressions rely on many fewer observations and random effects are more likely.

7.6.2.4 Variable Specification

The dependent variables examined in this logistic analysis are in-hospital mortality and one-year cumulative mortality, recorded as a 1 for death, 0 otherwise. Were mortality rates to exhibit an upward trend during the demonstration period, this would be disturbing, particularly given the controls made for patient severity. Death is not the only outcome of interest; other outcomes such as readmission rates, surgical complications and functional status are also important, and are discussed elsewhere in this report.

Table 7-15 describes the definitions of all independent variables used in the multivariate analysis. Dummy variables for three of the four hospitals are included in the regressions. The hospital with the lowest observed mortality rate appears as part of the intercept term. This specification effectively tests differences in mortality in the other three hospitals in a pairwise fashion with the low-rate hospital. Statistically insignificant coefficients (at the 10 percent level) for the three dummy variables implies no differences among any of the four hospitals.

The time trend used in the logistic analysis is a simple variable indicating the month during which an index CABG surgery was rendered. If the CABG surgery occurred during the first month of the demonstration, May 1991, then TREND equals 1. For patients undergoing CABG surgery during the last reported month, December 1993, the TREND equals 32. An alternative approach is to have a set of dummy variables indicative successive periods, but as a single monotonic variable, time-in-months has a parsimonious appeal. Alternatively, semi-annual dummies were tried with no differences in our conclusions.

A rich set of clinical data was available on nearly all patients. From this set, a smaller subset of critical risk factors was selected based on the literature and expert opinion. The variables included in the analysis are detailed in Table 7-15. Most of these specifications are straightforward. Age was specified in four categories, with the under-65 Medicare demonstration patients placed in the intercept. Inspection of the mortality data indicated breaks in death rates across these age groups. An alternative specification would include continuous age and squared age variable, but the categorical use of dummy variables was preferred on the grounds of interpretative ease. One issue of importance to the interpretation of the dummy variables is that the under-65 Medicare populations differ from the over-65 group, not only in age, but in health and eligibility status as well. Under-65 beneficiaries are disabled persons, often more severely ill than even older beneficiaries whose eligibility is based on age rather than disability. For example, the inpatient death rate among under-65 CABG patients here is less than 4 percent, while that for those under age 65 is around 3 percent. A reasonable argument can thus be made for placing the 65-69 group in the intercept. Nonetheless, we placed the under-65 patients in the intercept in order to avoid confusion.

TABLE 7-15

DESCRIPTION OF RISK FACTOR VARIABLES USED IN LOGISTIC MORTALITY ANALYSIS

Variables	Description
Hospital Dummy Variables	Each equals 1 if patient was discharged from that Hospital. Note that the referent hospital (the hospital omitted from the specification and appearing in the intercept term) changes depending on the regression;
Trend	equals 1 to 32 depending upon the month since the demonstration began that a patient was discharged (i.e., Trend=1 for May 1991, 32 for December 1993);
Urgent or Emergent	equals 1 if patient was admitted as urgent or emergent, respectively (= 0 if elective);
Unstable	equals 1 if patient was admitted with unstable angina (= 0 otherwise);
MI2Week	equals 1 if patient experienced a heart attack within two weeks prior to CABG surgery admission (= 0 otherwise);
Previous CABG	equals 1 if patient underwent CABG surgery previously (= 0 otherwise);
DRG 106	equals 1 if patient was admitted under DRG 106 (with catheterization) (= 0 for admission under DRG 107);
CHF	equals 1 if patient had Congestive Heart Failure (= 0 otherwise);
Diabetes	equals 1 if patient was diabetic (= 0 otherwise);
Stroke	equals 1 if patient has had a previous stroke or transient ischemic attack (= 0 otherwise);
COPD	equals 1 if patient is on medication for Chronic Obstructive Pulmonary Disease (= 0 otherwise);
Hyper	equals 1 if patient is hypertensive (= 0 otherwise);
Renal	equals 1 if patient has chronic renal insufficiency, with creatinine > 2 mg% (= 0 otherwise);
Age 65-69	equals 1 if the patient was between the age of 65 and 69 inclusive;

TABLE 7-15 (continued)

DESCRIPTION OF RISK FACTOR VARIABLES USED IN LOGISTIC MORTALITY ANALYSIS

Variables	Description
Age 70-74	equals 1 if the patient was between the age of 70 and 74 inclusive;
Age 75-79	equals 1 if the patient was between the age of 75 and 79 inclusive;
Age 80+	equals 1 if the patient was 80 years of age or older.
Female	equals 1 if patient was female.
Height	patient height in meters.
IABP	equals 1 if patient had an intra-aortic balloon pump inserted prior to surgery (=O otherwise);
Artery70	equals the number of arteries with 70 percent or more blockage;
LMCA	equals 1 if obstruction of Left Main Coronary Artery was 50% or greater (= 0 otherwise);
Ejection Fraction	reported patient left ventricular ejection fraction ;
Blood Use	number of red blood cell units used for treatment on patient.
Revascularization Index:	
Reop for Bleeding	equals 1 if the patient underwent a reoperation during the initial hospitalization because of bleeding (= 0 otherwise);
Reop for Other	equals 1 if the patient underwent a reoperation during the initial hospitalization for reasons other than bleeding (= 0 otherwise);
Post-Op AMI	equals 1 if the patient experienced a heart attack post-surgery during the hospitalization (= 0 otherwise);
Complications Dummy Variables	Each equals 1 if the patient suffered the particular complication post-surgery during the hospitalization (= 0 otherwise);
Inpatient Death	equals 1 if the patient died post-surgery during the hospitalization (= 0 otherwise).

Patient race, found in the interim report to be significantly associated with mortality, was omitted from this regression analysis because one site stopped reporting it during the last six months of 1993. It was felt that the importance of maintaining the integrity of the trend variable in the pooled analysis outweighed the value of keeping race in the model.

One key issue concerns the question of the point at which a risk factor is measured. Since a large part of this evaluation concerns trends in outcomes over time, most of the logistic mortality analysis relies strictly on pre-operative risk assessment variables in order to avoid bias in the time trend variable. Inclusion of post-operative risk variables biases the trend, because those same post-operative complications could be the result of a downward trend in hospital performance during the demonstration. Analysis of the time trend, therefore, makes use only of pre-operative risk data. Following our discussion of the trend findings, we step in post-operative complications in order to better assess the mortality impacts of the patient risk factors themselves, independent of complications.

Our inclusion among the pre-operative variables of insertion of intra-aortic balloon pump (IABP) is worthy of note. While use of IABP may be thought as a part of the surgery itself, we chose to include it as a pre-operative risk variable, as its use suggests the presence of substantial patient risks that are perhaps not captured elsewhere in the model. IABP is used only on the sickest of patients, or those with the weakest cardiac output. Its inherent risks (it carries a high added risk of infection, and can necessitate amputation of the leg) suggest that those patients are among the most severe cases.

7.6.2.5 Bias and Specification Issues

Hospital dummy variables, a time trend, and patient risk factors are included in a fixed effects format in Model 3. Since the principal focus of the multivariate analysis is to assess any time trend in outcomes over the period of the demonstration, obtaining an unbiased time trend coefficient is critically important. The inclusion of patient risk factors in this model was motivated by this concern. The patient risk factor variables will pick up differences in severity of casemix over time, and the hospital dummy variables will pick up the effects of casemix differences between sites and possibly some effects on outcomes from unmeasured variables. Hopefully, this leaves the time trend coefficient estimate unbiased.

There is a potentially serious problem with the generalizability of the results from this specification, however, since only four hospitals were examined, and random variation cannot be assumed. With only four hospitals, we cannot assume that the relative risk estimates for the patient risk factors obtained from this analysis are representative of all hospitals, particularly

given the selection process for participation in the demonstration. The focus of the analysis, however, is not on the risk factors themselves, but on the time trend coefficient.

The question of how to include risk factors into the model depends upon one's assumptions about causality and consistency in measurement. By entering risk factors in non-interacted form, as in this analysis, and pooling the data across hospitals, one assumes that risk factor coefficients and their associated marginal effects are equal across the four facilities. On the other hand, it is possible that one hospital is much better at treating very sick patients but no different in treating the average patient. This second possibility is addressed by the within-site regressions.

7.6.2.6 The Confidence Level

As evaluators, we must balance the need to be confident that a trend in mortality exists with the desire to avoid overlooking a trend, particularly an adverse one. A Type II error occurs when a null hypothesis of no significant effect is accepted, when, in fact, one exists. In the case of the trend variable, it is crucial to avoid such an error. Inconsistencies in reporting, as well as differences in risk factor definitions, could easily result in an underestimate of the true correlation between the risk factors and mortality. Insistence on a high confidence threshold might cause us to reject a pertinent risk factor or the time trend simply because the variable was not always accurately reported.

For these reasons, a 10 percent confidence level was used as the standard for assessing statistical significance, rather than the more common 5 or 1 percent level. This is a conservative threshold, but in evaluating whether the time trend in mortality is changing over the course of the demonstration, it is crucial to avoid a Type II error.

7.6.3 Logistic Time-Trend Results on Inpatient and Post-Surgery Mortality

7.6.3.1 Time Trend Results on Inpatient Mortality

Table 7-16 reports odds ratios and p-values for the four in-hospital mortality models. Coefficient estimates themselves are not reported because they are not directly interpretable; attention is instead focused on odds ratios that indicate the degree to which the presence of a risk factor affects mortality. The overall model Chi-Square (and p-value) and the number of observations are included at the bottom of each regression.

Model 1 contains only the three dummy variables indicating the hospital at which the CABG surgery occurred with Hospital C embedded in the intercept. None of these hospital dummy variables are significant. Model 2 includes the same hospital dummy variables, as well

TABLE 7-16

POOLED INPATIENT MORTALITY LOGISTIC RESULTS

	Model 1		Model 2		Model 3		Model 4	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	.04 ***	.00	.04 ***	.00	1.18	.93	1.14	.92
HOSPITAL A	1.12	.56	1.14	.52	1.27	.47	-	-
HOSPITAL B	1.22	.44	1.23	.42	.96	.91	-	-
HOSPITAL D	1.09	.78	1.11	.74	1.33	.47	-	-
TREND	-	-	1.01	.27	.99	.21	-	-
URGENT	-	-	-	-	1.65 *	.10	-	-
EMERGENT	-	-	-	-	2.63 ***	.00	2.41 ***	.00
UNSTABLE	-	-	-	-	1.55	.12	-	-
MI2WEEK	-	-	-	-	1.41	.28	-	-
PREVIOUS CABG	-	-	-	-	4.58 ***	.00	4.50 ***	.00
DRG 106	-	-	-	-	1.44 *	.08	1.60 **	.01
CHF	-	-	-	-	1.35	.20	1.53 *	.05
DIABETES	-	-	-	-	1.66 **	.01	1.76 ***	.00
RENAL	-	-	-	-	2.29 ***	.00	2.21 ***	.00
COPD	-	-	-	-	1.62 **	.04	1.59 **	.04
STROKE	-	-	-	-	1.18	.56	-	-
HYPER	-	-	-	-	1.18	.42	-	-
AGE 65-69	-	-	-	-	.90	.77	-	-
AGE 70-74	-	-	-	-	1.29	.49	-	-
AGE 75-79	-	-	-	-	1.91 *	.09	1.89 ***	.00
AGE 80+	-	-	-	-	2.39 **	.04	2.54 ***	.00
FEMALE	-	-	-	-	1.12	.66	-	-
HEIGHT	-	-	-	-	.10 **	.03	.12 ***	.00
IABP	-	-	-	-	3.01 ***	.00	3.01 ***	.00
ARTERY70	-	-	-	-	1.01	.97	-	-
LMCA	-	-	-	-	1.13	.57	-	-
EJECTION FRACTION	-	-	-	-	.97 ***	.00	.98 ***	.00
No. Observations	3,574		3,572		2,920		3,126	
Overall Chi-Square (P-Value)	0.64	9.89	1.86	0.76	162.61	0.0001	161.1	0.0001

NOTE

*** indicates significance at the .01 level, ** at the .05 level, and * at the .10 level

Model 4 was developed by selecting those independent variables from from Model 3 for which p< 2, and entering them forward stepwise with the criterion that p< 10 (see text)

SOURCE Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992

as the monthly trend variable. The hospital dummy variables remain insignificant in Model 2, and their direction and magnitudes are all but unaffected by inclusion of the time trend variable, which is insignificant as well. We conclude that even in the absence of any controls for patient severity, inpatient mortality among these three sites does not differ significantly from Hospital C, nor has there been any statistically discernible trend in pooled mortality among the four sites over the 32 months during which the demonstration has taken place.

Model 3 includes the hospital dummy variables, trend, and the complete set of patient risk factors. The number of observations in Model 3 (N=2,920) is substantially smaller than those for Models 1 and 2 (N=3,574 and 3,572, respectively) due to missing values for the large set of variables included in Model 3. The magnitude and direction of the hospital dummies are little affected by the inclusion of the patient risk variables, indicating no significant correlation between site and patient severity. This further supports the hypothesis of no site differences in inpatient mortality. The time trend odds ratio, an insignificant 1.01 (p=.27) in Model 2, changes direction with the inclusion of the patient risk factors to .99 (p=.21), but remains insignificant (note again that negative coefficients produce odds ratios between zero and one, and positive coefficients produce odds ratios greater than one).

Many of the patient risk factors, however, are highly significant in Model 3. Revascularization priority (urgent, emergent) appears to affect inpatient mortality. CABG patients described as "urgent" have an inpatient mortality odds ratio of 1.65, compared to elective patients, though this variable is only marginally significant at p=.10. "Emergent" cases have an odds ratio of 2.63 (p<.01). An urgent case is 65 percent more likely to die in-hospital than a non-urgent case, while an emergent case is over two and one half times more likely to die in-hospital. The effect of clinical presentatior (unstable, MI2WEEK) is not as strong. Unstable patients seem to have a greater propensity to die in-hospital, but their odds ratio of 1.55 differs from unity only at p=.12. A clinical presentation of AMI within two weeks, surprisingly, does not significantly affect in-hospital mortality.

The risks of inpatient mortality associated with having undergone CABG surgery previously was greater than that from any other risk factor examined here. Those patients with a previous bypass surgery had an odds ratio of 4.58 (p<.01). This variable very likely captures high levels of illness severity that are not measured elsewhere in the model.

Not surprisingly, patients admitted under DRG 106 (bypass with catheterization) are more likely to die in-hospital than patients admitted under DRG 107(bypass without catheterization). We would expect those patients given catheterization and bypass surgery during the same stay to be at least as severe, and often more severe, than those who were transferred from another institution or who took time out-of-hospital to consider the risks and benefits of surgery.

Three of the comorbid illnesses greatly increase the risk of inpatient mortality. Diabetes, chronic renal insufficiency, and chronic obstructive pulmonary disease were all significant at p<.05 or better, with odds ratios of 1.66, 2.29, and 1.62, respectively. Congestive heart failure, hypertension and stroke do not have a significant effect on in-hospital mortality, *ceteris paribus*.

CABG patients in the two oldest age cohorts face significantly increased risks of inpatient mortality compared to under-65 patients. Those aged 75-79 have an odds ratio of 1.91, though this is barely significant at p=.09. Those over 80 are clearly at much higher risk, being more than twice as likely to die while in the hospital (odds ratio = 2.39, p=.04) than patients under age 65.

Taller patients are found to be at significantly lower risk of dying in the hospital, which is consistent with physiologic differences in artery diameter between taller and shorter persons. The odds ratio of .10 (p<.03), however, is not very meaningful, as the variable is measured in meters. Expressed as an estimate of the differential risk associated with a change in height of six inches, this odds ratio becomes .71, meaning that being six inches taller is associated with an inpatient mortality risk only 71 percent as great as that for shorter persons, *ceteris paribus*. The 3-inch difference-in-height odds ratio is .84. Note that all these scaled odds ratios maintain the property of a statistically significant difference from unity. The female variable, insignificant in this regression, might be dominated by the height variable, due to their obvious high correlation.

The insertion of an intra-aortic balloon pump prior to surgery is associated with greatly increased in-hospital mortality risk. The IABP odds ratio is 3.01 (p<.01).

Except for ejection fraction, the anatomy of coronary disease as measured here has no predictive power for inpatient mortality. The presence of an obstruction of more than 50 percent in the left main coronary artery (LMCA) is insignificant, as is the number of arteries with at least 70 percent blockage. Left ventricular ejection fraction, however, is highly significant (p<.01), with a higher ejection fraction associated with lower risk of inpatient mortality. The odds ratio of .97 indicates that an increase of 1 percentage point in ejection fraction is associated with a 3 percent decrease in risk of inpatient mortality. Scaled to represent an increase in ejection fraction of ten percentage points, this odds ratio becomes .74; for an increase of twenty percentage points, .54; the interpretation of this last odds ratio would be that a patient with an ejection fraction twenty percentage points higher has an in-hospital mortality risk only 54 percent as great as that for a patient with a lower ejection fraction.

Model 4 was constructed using the variables contributing the most to Model 3 (the exact selection criteria are discussed above). Being comprised of fewer variables then Model 3, Model 4 suffers from fewer missing data problems, and the sample size (N=3,126) is therefore

larger. Generally speaking, the magnitudes of the relative risk estimates in this regression do not differ greatly from their counterparts in Model 3. The statistical power of these new estimates, however, is much better in most cases, suggesting that these estimates are more reliable. Some notable apparent differences include the odds ratio for emergent cases, down slightly from 2.63 to 2.41, and congestive heart failure, up from an insignificant 1.35 to a significant 1.53 (at the 10 percent level). Note, however that these apparent differences are not necessarily meaningful; a .05 confidence internal for the CHF odds ratio of 1.53 would subsume 1.35. The relative risk estimates in Model 4 for height, scaled to represent an increase of six inches, is .73; for ejection fraction, scaled to represent an increase of 10 percentage points, the odds ratio is .82.

To summarize, the key findings in the inpatient mortality logistic analysis is that there is no significant overall time trend in mortality among the original four sites, and no significant site-differences.

Table 7-17 reports mean values by hospital for the 22 variables included in Model 3. Many of the less rigorously defined risk factors exhibit such wide variation across hospitals as to suggest differences in institutional definition. A revascularization priority of urgent is far less frequent at Hospital B than at other sites: 2 percent of CABG patients, compared to 49, 61 and 55 percent at Hospitals A, C, and D, respectively. Patients with a clinical presentation of "unstable" comprised only a quarter of cases at Hospital C, while comprising 54, 62 and 83 percent at A, B and D, respectively. The likelihood of a patient having a previous CABG quite similar at three of the hospitals while Hospital D was less than half as likely to be performing a "redo".

The prevalence of congestive heart failure and chronic obstructive pulmonary disease also fluctuated substantially across sites, with CHF ranging from 12 to 28 percent, and COPD from 10 to 27 percent. The rate of use of IABP prior to surgery, a critical risk factor, was only 1 percent of Hospital C, but was 6-7 percent at Hospital A and D. Not surprisingly, age, gender and height distributions differed little across sites.

Table 7-18 reports mean values (pooled across sites) for five different time periods for the 22 regressor variables. The first period is the first 8 months of the demonstration (May 1991 through December 1991), the next four are each six months, for a total of 32 months. A quick general examination of these mean values suggests a trend towards a more severe pooled patient mix during the later periods of the demonstration. While the results for clinical presentation and revascularization priority are mixed, those for comorbid illnesses (CHF, diabetes, renal insufficiency, COPD, stroke, and hypertension) appear to have a trend towards greater prevalence in later periods. The proportion of CABG patients who have previously undergone bypass surgery is on a steady, if slow, increase, as is the number of cases with

TABLE 7-17

MEAN VALUES BY HOSPITAL FOR RISK FACTORS USED IN INPATIENT MORTALITY LOGISTIC ANALYSIS

Variable	Hospital A (N=541)	Hospital B (N=1377)	Hospital C (N=712)	Hospital D (N=295)
URGENT	.49	.02	.61	.55
EMERGENT	.10	.16	.09	.08
UNSTABLE	.54	.62	.25	.83
MI2WEEK	.13	.26	.16	.08
PREVIOUS CABG	.08	.10	.09	.04
DRG 106	.40	.40	.55	.66
CHF	.28	.13	.12	.09
DIABETES	.29	.25	.30	.31
RENAL	.11	.15	.05	.10
COPD	.11	.27	.10	.11
STROKE	.12	.09	.08	.11
HYPER	.74	.58	.66	.69
AGE 65-69	.26	.31	.37	.33
AGE 70-74	.33	.34	.30	.26
AGE 75-79	.24	.18	.19	.17
AGE 80+	.09	.07	.09	.06
FEMALE	.40	.33	.31	.37
HEIGHT	1.68	1.73	1.70	1.70
IABP	.07	.02	.01	.06
ARTERY70	2.38	2.41	2.37	2.61
LMCA	.24	.26	.21	.15
EJECTION FRACTION	53.56	48.56	41.99	56.40

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992.

TABLE 7-18

MEAN VALUES BY PERIOD FOR RISK FACTORS USED IN INPATIENT MORTALITY LOGISTIC ANALYSIS

VARIABLE	May '91-Dec. '91 (N=563)	Jan. '92-June '92 (N=534)	July '92-Dec. '92 (N=513)	Jan. '93-June '93 (N=687)	July '93-Dec. '93 (N=628)
URGENT	.22	.31	.31	.36	.31
EMERGENT	.14	.11	.12	.14	.12
UNSTABLE	.56	.53	.51	.54	.51
MI2WEEK	.18	.19	.19	.17	.24
PREVIOUS CABG	.07	.07	.08	.11	.10
DRG 106	.45	.46	.45	.47	.48
CHF	.12	.16	.16	.17	.13
DIABETES	.17	.31	.33	.27	.29
RENAL	.05	.07	.09	.15	.19
COPD	.18	.19	.14	.19	.20
STROKE	.05	.10	.09	.09	.13
HYPER	.53	.64	.61	.66	.74
AGE 65-69	.31	.29	.32	.33	.33
AGE 70-74	.32	.33	.31	.33	.32
AGE 75-79	.20	.21	.20	.17	.18
AGE 80+	.07	.09	.08	.07	.10
FEMALE	.36	.32	.34	.37	.31
HEIGHT	1.71	1.71	1.72	1.70	1.72
IABP	.03	.03	.04	.04	.02
ARTERY>70	2.36	2.38	2.43	2.42	2.47
LMCA<50	.21	.20	.24	.26	.25
EJECTION FRACTION	51.17	48.54	47.99	48.17	47.69

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992.

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TABLE 7-19

MEAN VALUES BY HOSPITAL AND PERIOD FOR RISK FACTORS INCLUDED IN INPATIENT MORTALITY LOGISTIC ANALYSIS

	HOSPITAL A				
	PERIOD 1	PERIOD 2	PERIOD 3	PERIOD 4	PERIOD 5
URGENT	.50	.57	.48	.60	.23
ERMERGENT	.16	.09	.09	.11	.01
UNSTABLE	.51	.63	.63	.64	.20
MI2WEEK	.06	.05	.01	.05	.59
PREVIOUS CABG	.06	.10	.08	.09	.09
DRG 106	.46	.38	.38	.38	.37
CHF	.20	.31	.40	.36	.13
DIABETES	.28	.32	.36	.25	.28
RENAL	.10	.05	.11	.13	.15
COPD	.11	.06	.13	.18	.08
STROKE	.16	.12	.11	.11	.12
HYPER	.72	.72	.69	.74	.83
AGE 65-69	.29	.26	.19	.26	.33
AGE 70-74	.33	.32	.38	.31	.32
AGE 74-79	.27	.28	.22	.19	.24
AGE 80+	.07	.11	.11	.07	.10
FEMALE	.39	.38	.42	.43	.35
HEIGHT	1.68	1.69	1.68	1.67	1.70
IABP	.10	.06	.05	.10	.00
ARTERY 70	2.21	2.42	2.48	2.43	2.41
LMCA	.24	.19	.24	.28	.24
EJECTION FRACTION	55.53	54.75	53.21	51.45	54.41

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992.

TABLE 7-19 (continued)

MEAN VALUES BY HOSPITAL AND PERIOD FOR RISK FACTORS INCLUDED IN INPATIENT MORTALITY LOGISTIC ANALYSIS

	HOSPITAL B				
	PERIOD 1	PERIOD 2	PERIOD 3	PERIOD 4	PERIOD 5
URGENT	.00	.02	.02	.03	.05
ERMERGENT	.16	.15	.18	.18	.14
UNSTABLE	.58	.56	.58	.65	.68
MI2WEEK	.26	.29	.26	.23	.26
PREVIOUS CABG	.09	.06	.09	.13	.11
DRG 106	.38	.42	.47	.38	.39
CHF	.09	.14	.13	.13	.14
DIABETES	.07	.32	.30	.29	.29
RENAL	.01	.09	.12	.23	.31
COPD	.26	.28	.19	.26	.34
STROKE	.00	.09	.10	.09	.15
HYPER	.41	.60	.55	.62	.75
AGE 65-69	.30	.25	.35	.33	.32
AGE 70-74	.34	.33	.31	.36	.34
AGE 74-79	.20	.21	.20	.15	.16
AGE 80+	.07	.10	.05	.06	.08
FEMALE	.35	.31	.47	.35	.30
HEIGHT	1.71	1.72	1.74	1.72	1.75
IABP	.02	.02	.03	.02	.02
ARTERY 70	2.37	2.33	2.39	2.42	2.51
LMCA	.25	.21	.03	.26	.29
EJECTION FRACTION	49.36	47.94	48.21	49.04	48.03

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992.

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TABLE 7-19 (continued)

MEAN VALUES BY HOSPITAL AND PERIOD FOR RISK FACTORS INCLUDED IN INPATIENT MORTALITY LOGISTIC ANALYSIS

	HOSPITAL C				
	PERIOD 1	PERIOD 2	PERIOD 3	PERIOD 4	PERIOD 5
URGENT	.51	.58	.59	.65	.62
ERMERGENT	.09	.11	.05	.09	.11
UNSTABLE	.16	.20	.21	.25	.33
MI2WEEK	.25	.19	.22	.15	.09
PREVIOUS CABG	.11	.10	.06	.10	.10
DRG 106	.54	.52	.43	.60	.60
CHF	.12	.09	.10	.14	.12
DIABETES	.33	.29	.34	.27	.30
RENAL	.00	.02	.07	.06	.05
COPD	.04	.13	.10	.11	.07
STROKE	.05	.11	.06	.05	.11
HYPER	.60	.59	.66	.68	.70
AGE 65-69	.46	.38	.35	.38	.33
AGE 70-74	.28	.34	.27	.30	.32
AGE 74-79	.14	.19	.21	.20	.19
AGE 80+	.07	.08	.10	.07	.12
FEMALE	.30	.27	.31	.35	.29
HEIGHT	1.70	1.70	1.71	1.70	1.70
IABP	.00	.01	.02	.03	.01
ARTERY 70	23.26	2.40	2.42	2.30	2.41
LMCA	.09	.23	.24	.25	.19
EJECTION FRACTION	40.53	42.80	41.50	42.30	42.00

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992.

TABLE 7-19 (continued)

MEAN VALUES BY HOSPITAL AND PERIOD FOR RISK FACTORS INCLUDED IN INPATIENT MORTALITY LOGISTIC ANALYSIS

	HOSPITAL D				
	PERIOD 1	PERIOD 2	PERIOD 3	PERIOD 4	PERIOD 5
URGENT	.42	.54	.44	.65	.67
ERMERGENT	.08	.02	.68	.09	.14
UNSTABLE	.97	.98	.83	.65	.77
MI2WEEK	.03	.02	.10	.13	.12
PREVIOUS CABG	.02	.04	.02	.06	.07
DRG 106	.64	.67	.56	.68	.75
CHF	.11	.09	.04	.12	.07
DIABETES	.33	.35	.38	.21	.30
RENAL	.14	.15	.00	.09	.12
COPD	.11	.17	.10	.09	.07
STROKE	.06	.06	.08	.16	.16
HYPER	.66	.74	.62	.68	.75
AGE 65-69	.31	.30	.33	.32	.37
AGE 70-74	.23	.28	.27	.28	.23
AGE 74-79	.17	.15	.17	.16	.19
AGE 80+	.03	.02	.06	.09	.09
FEMALE	.38	.35	.31	.43	.37
HEIGHT	1.72	1.71	1.70	1.69	1.70
IABP	.02	.02	.10	.09	.07
ARTERY 70	2.66	2.48	2.56	2.71	2.60
LMCA	.06	.07	.17	.21	.25
EJECTION FRACTION	60.17	52.98	55.44	55.04	57.91

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992.

LMCA blockage of more than 50 percent and the number of arteries with at least 70 percent blockage. Ejection fraction, a variable for which higher values are hypothesized to be associated with a lower risk of mortality, is steadily decreasing.

7.6.3.2 Within-Hospital Inpatient Mortality Logistic Results

The possibility that the demonstration might result in differing time trends by hospital motivated within-site logistic inpatient mortality analysis. While no trend may be discerned at the aggregate pooled level, providers may be responding to the demonstration's incentives in an unusual manner. The results of our within-site logistic regressions are reported in Table 7-20. The risk factors chosen for these regressions are those appearing in Model 4 (i.e., those satisfying the two-stage significance criteria discussed earlier). While these within-site regressions offer insights into how the demonstration affects individual institutions, they suffer the drawback of much smaller sample sizes than those seen in the pooled analysis. Institutional-level inferences are therefore more difficult to draw.

The key finding among the site-specific regressions in Table 7-20 concerns the time trend. This variable, insignificant in all pooled logistic inpatient mortality models discussed earlier, is highly significant ($p<.05$) in the Hospital A regression, with an odds ratio less than unity, indicating a decrease in inpatient mortality during the 32 months of the demonstration. Hospital A's mortality rate has declined steadily during the 32 months of the demonstration, from an annualized rate of 6.7 percent in 1991, to 5.9 in 1992, and finally, 3.2 in 1993 (see Table 7-2). Apparently large mortality changes such as these could be due to several factors, including hospital performance and patient case mix. Even controlling for the latter, however, we see a downward trend in mortality.

Table 7-19 shows the mean values by hospital by period for all the risk factors analyzed in the full inpatient model. It was mentioned earlier in the pooled inpatient mortality analysis that many measures of patient severity suggested a more severe case/mix in the later periods of the demonstration. This apparent upward trend in severity among the pooled group of patients, however, is not present among Hospital A's patients, explaining at least in part the fall in mortality at Hospital A. Of the variables that are significant in Hospital A's regression, only chronic renal insufficiency and age over 80 appear to be higher in the later periods of the demonstration. The decrease in mortality in the Hospital A regression, furthermore, is not only statistically significant, but quantitatively large. The odds ratio of .93 estimates the relative risk of one month's difference. Scaled to represent one year, this odds ratio becomes .38, indicating that patients undergoing CABG one year later are less than two-fifths as likely to die in the

TABLE 7-20

WITHIN-SITE INPATIENT MORTALITY LOGISTIC RESULTS

	Hospital A		Hospital B		Hospital C		Hospital D	
VARIABLE	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	.02	.37	16.83	.16	.06	.34	66.30	.42
TREND	.93 **	.01	.99	.51	1.04	.14	1.03	.46
EMERGENT	2.23	.23	2.67 ***	.00	3.08 **	.04	1.86	.52
PREVIOUS CABG	4.51 **	.04	3.50 ***	.00	9.04 ***	.00	7.17 **	.05
DRG 106	2.63 *	.05	1.51	.13	1.20	.67	1.88	.38
CHF	1.60	.37	1.34	.39	2.03	.15	1.85	.49
DIABETES	2.83 **	.03	1.87 **	.03	1.16	.74	2.[illegible]0	.27
RENAL	4.79 ***	.00	1.88 **	.05	2.59	.11	3.70 *	.09
COPD	7.53 ***	.00	1.04	.90	2.83 *	.06	1.52	.72
AGE 75-79	1.70	.35	1.55	.16	3.03 **	.02	2.43	.26
AGE 80+	9.76 ***	.00	1.00	.99	4.18 ***	.01	3.23	.22
HEIGHT	.98	.99	.04 ***	.00	.17	.26	.02	.18
IABP	3.22 *	.10	4.77 ***	.00	12.27 ***	.00	.30	.38
EJECTION FRACTION	.99	.38	.97 ***	.00	1.00	.91	.95 **	.04
No. Observations	544		1,560		755		296	
Overall Chi-Square	57.3	.0001	90.7	.0001	51.9	.0001	17.5	.18

*** indicates significance at the .01 level, ** at the .05 level, * at the .10 level

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992

hospital as those operated on earlier, controlling for the risk factors having the greatest impact on mortality.

Table 7-20 reports that no site other than Hospital A showed a significant trend in inpatient mortality during the 32 months of the demonstration. Hospital C's trend variable came relatively close to significance, however, with an odds ratio of 1.04 and p=.14.

The risk variables included in these within-site regressions were not, in general, as significant as they were in the pooled analysis, no doubt due largely to reduced sample sizes. Admission under DRG 106, for example, was statistically significant only in Hospital A, while congestive heart failure was not significant at any hospital. Only the previous CABG surgery variable--the variable with the greatest quantitative impact on mortality risk in the pooled model--was significant in all four site-specific regressions, although renal insufficiency was almost significant in Hospital C.

Those variables that are significant differ substantially by hospital, suggesting that hospitals might differ in their ability to cope with comorbid illnesses and other risk factors. Take, for example, diabetes and chronic renal disease. Hospital A shows large and significant increases in inpatient mortality risk associated with diabetes and renal disease; these same increased risks are significant for Hospital B as well, but appear quantitatively much smaller. The diabetes odds ratios for Hospitals A and B are 2.83 versus 1.87 (both $p<.05$), while those for renal disease are 4.79 versus 1.88 ($p<.01$ and $p<.05$, respectively). Hospital C shows no significantly increased risk from either diabetes or renal disease, and Hospital D shows increased risk only for renal disease.

COPD, which has a very large and significant effect on inpatient mortality at Hospital A (odds ratio 7.53, $p<.01$), has no statistically significant effect at B or D, and a smaller, less-significant effect at Hospital C (odds ratio 2.83, $p<.10$).

The effect of age also differed by hospital. Only Hospital C showed significantly increased risk for patients aged 75-79 (odds ratio 3.03, $p<.05$). Hospitals A and C both showed large and highly significant increases in risk associated with patients 80 and older, with odds ratios of 9.76 and 4.18 (both $p<.01$). It is important to note that these two age odds ratios in the site-specific regressions differ in their interpretation from those in the full pooled model. Since the only age variables in these site-specific regressions represent age groups 75-79 and 80 and over, their odds ratios are interpreted relative to under-75 patients. The odds ratios in Model 3 of Table 7-16 are interpreted relative to under-65 patients. It is still surprising that mortality risks are no higher for older patients in Hospital B, essentially given its large sample size.

Insertion of an IABP prior to surgery shows very large significant increases in risk at Hospitals A, B and C (odds ratios of 3.22, 4.77 and 12.27, respectively, $p<.10$ and $p<.01$). Height significantly affected mortality risk only at Hospital B, and its association with reduced

risk of mortality was even more dramatic than in the pooled regression. Scaled to estimate the relative risk of being six inches taller, the odds ratio becomes .62, or 38 percent less likely to die.

Ejection fraction is significant only at Hospitals B and D (notably, it is one of only three variables significant at Hospital D, the site with the fewest observations). Scaled to estimate the relative risk of having a 10-percentage point higher ejection fraction, the odds ratios become .74 and .61 ($p<.01$ and $p<.05$), respectively.

The key finding from the within-site inpatient mortality model is that no site had a statistically significant upward trend in inpatient mortality during the 32 months of the demonstration, controlling for those patient risk factors having the strongest effect on inpatient mortality. Hospital A actually showed a significant downward trend during the demonstration.

7.6.3.3 Results of Pooled Logistic One-Year Mortality Regressions

Inpatient mortality, obviously an important outcome measure for CABG surgery, is not the only measure of interest. Since the risks from CABG surgery extend to periods far longer than the actual hospital stay, it is important to examine mortality outcomes over a longer period. We have chosen cumulative one-year mortality as our longer-term outcome measure. In this analysis we replicate the basic mortality model seen in the inpatient mortality analysis; pre-operative patient risk factors, hospital dummy variables, and the time trend variable serve again as independent variables, where the dichotomous variable is now cumulative one-year mortality.

The one-year mortality logistic analysis, like the inpatient mortality analysis, is confined to the original four participating hospitals, because the late entry of the last three hospitals would make interpretation of the time trend difficult. All records with a CABG surgery date after December 1992 are excluded, because one-year follow-up data were available only through 1993, and the sample sizes for the one-year mortality logistic analysis are much smaller than those for the inpatient mortality analysis,

Table 7-21 reports the results from three logistic regressions. The first, Model 5, is the full pre-operative risk factor model with hospital dummy variables and time trend (this specification is identical to the general one used for the inpatient mortality model). Its dependent variable is cumulative one-year mortality. The second model, Model 6, is a deleted model developed using the same method used for the deleted inpatient model; all variables with a p-value of less than .2 in the full model were selected as candidate variables to be entered into a forward stepwise logistic regression, and were kept in the regression with the criterion that $p<.10$. The third model, Model 7, is a similarly-deleted model with inpatient

TABLE 7-21

POOLED CUMULATIVE ONE-YEAR MORTALITY LOGISTIC RESULTS AND INPATIENT MORTALITY LOGISTIC RESULTS
EXCLUDING PATIENTS UNDERGOING CABG SURGERY AFTER DECEMBER 1992

	Model 5 Full One-Year Mortality		Model 6 Deleted One-Year Mortality		Model 7 Deleted Inpatient Mortality	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	.41	.70	.14 ***	.00	2.19	.64
HOSPITAL B	2.26 **	.04	-	-	-	-
HOSPITAL A	3.09 ***	.00	1.63 **	.04	-	-
HOSPITAL D	1.94	.20	-	-	-	-
TREND	.99	.48	-	-	-	-
URGENT	1.16	.64	-	-	-	-
EMERGENT	1.44	.26	-	-	2.93 ***	.00
UNSTABLE	1.01	.97	-	-	-	-
MI2WEEK	1.20	.60	-	-	-	-
PREVCABG	3.18 ***	.00	3.31 ***	.00	6.14 ***	.00
DRG 106	1.28	.27	-	-	-	-
CHF	2.02 ***	.01	2.24 ***	.00	2.18 ***	.01
DIABETES	1.06	.82	-	-	2.03 ***	.01
RENAL	2.18 **	.01	2.70 ***	.00	2.04 **	.05
COPD	1.50	.12	-	-	-	-
STROKE	1.28	.46	-	-	-	-
HYPER	1.23	.36	-	-	-	-
AGE 65-69	.66	.28	-	-	-	-
AGE 70-74	.74	.40	-	-	-	-
AGE 75-79	.94	.86	-	-	-	-
AGE 80+	1.81	.17	2.40 ***	.00	2.21 **	.03
FEMALE	.86	.59	-	-	-	-
HEIGHT	.28	.31	-	-	.05 ***	.00
IABP	2.50 **	.02	3.19 ***	.00	3.79 ***	.00
ARTERY70	1.17	.26	-	-	-	-
LMCA	.86	.57	-	-	-	-
EJECTION FRACTION	.98 ***	.01	.97 ***	.00	-	-
No. Observations	1,577		1,785		1,739	
Overall Chi-Square	101.3	.0001	91.9	.0001	89.3	.0001

NOTE:
*** indicates significance at the .01 level, ** at the .05 level, and * at the .10 level.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

The deleted one-year mortality model was developed by selecting those independent variables from the full one-year mortality model for which p<2, and entering then forward stepwise with the criterion that p<.10 (see text). The deleted inpatient mortality model is not the same one seen in Table 7-6-2-1. A logistic regression was run with a specification identical to that in Model 3 of Table 7-6-2-1, but with the sample limited to those patients with a date of CABG surgery before January 1993, making the cohort roughly identical to that examined in the one-year mortality regression. A forward deleted model was then developed using those independent variables for which p<2, again based on the entry criterion that p<1. The coefficients in the inpatient and one-year mortality regressions above are therefore generated from roughly the same sample of patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992. Information on one-year mortality is from the Medicare Enrollment files, 1991-1993.

mortality as its dependent variable. It is included here so that its odds ratios can be compared directly to those for the one-year mortality logistic regression. Note that Model 7 is not the same as Model 4, the deleted model seen in Table 7-16 and discussed in the inpatient mortality regression section; Model 4 was generated from Model 3, using the full cohort of demonstration patients (N=3,126). Model 9 was generated from a full inpatient mortality model that excluded patients undergoing CABG surgery after December 1992 in order to make the odds ratio comparison with Model 6 more valid.

We begin our discussion with Model 5. The dummy variables representing Hospitals B and A are highly significant, and suggest substantially increased one-year mortality risk relative to patients at the referent (Hospital C), controlling for pre-operative risk factors. Hospital B has an odds ratio of 2.26 ($p<.05$), suggesting that its patients are more than twice as likely to die within one year of surgery as those at Hospital C, *ceteris paribus*. Hospital A's odds ratio is even larger at 3.09 ($p<.01$). These differences may be due to unmeasured risk factors or differences in medical care services across sites.

There is no evidence of a time trend in one-year mortality, as the trend variable is insignificant ($p=.48$). It should be noted, however, that this result pertains only to patients undergoing CABG surgery in 1991-1992. We cannot conclude that there has been no time trend in one-year mortality for the full period of the demonstration (May 1991 to December 1993) because one-year mortality data were not available for 1993 CABG patients. The trend variable in Model 5 has an odds ratio of 1.94, with a p-value of .20; while this is insignificant, it is entirely possible that the inclusion of the 1993 patients would make the trend more significant.

Relatively few of the pre-operative risk factors are significantly related to one-year mortality. Neither the revascularization priority nor the clinical presentation of a CABG patient has a significant effect. Of the comorbid risk factors, only congestive heart failure (odds ratio = 2.02, $p<.01$) and renal insufficiency (odds ratio = 2.18, $p<.05$) significantly increase risk, both making a patient about twice as likely to die within one year.

Surprisingly, none of the age dummy variables were significant in the one-year mortality regression. Even the dummy variable representing persons over 80 years of age had a p-value of .17, implying that the very elderly were not more likely to die within one year of surgery. And patient height, a strong predictor of inpatient mortality, is insignificant as well.

Previous CABG, IABP, and ejection fraction, however, are all significant, as they were in the inpatient mortality regression. Previous CABG, mentioned earlier to be a variable that likely captures patient severity not measured elsewhere in the model, is robustly significant with an odds ratio = of 3.18 ($p<.01$). IABP is also significant, with an odds ratio of 2.50 ($p<.02$). Higher ejection fractions contribute significantly to lower one-year mortality risk. Scaled to

estimate the relative risk of a 5 percentage point higher ejection fraction, the odds ratio becomes .89; for 10 percentage points, .78; implying a 22 percent less likely chance of dying for a 10 percentage point higher ejection fraction.

Model 6 reports the results from the deleted cumulative mortality model. Notably, the only hospital dummy variable that met the significance criterion was that for Hospital A. Its odds ratio in this deleted model is 1.63 ($p<.05$). Hospital B's dummy variable, significant at $p<.05$ in the full model, was rejected by the stepwise process for the deleted model. Deleting insignificant variables increases the sample by over 10 percent, which may explain coefficient changes. Multicollinearity in the full model may also have created a "false positive" difference for Hospital B versus C.

The other notable coefficient change in the deleted model is seen in the case of the AGE80+ variable. Its odds ratio went from an insignificant 1.81 ($p=.17$) to 2.40 ($p<.01$).

Important differences exist between the deleted one-year mortality model, Model 8, and its inpatient mortality counterpart, Model 9. First, Hospital A's patients in this cohort are significantly more likely to die within on year than are other patients, but no more likely to die while in the hospital. Hospital A's odds ratio is 1.63 ($p<.05$) in the one-year mortality model, implying a 63 percent likelihood of dying within one year versus Hospital C.

Notably, emergent cases, diabetic patients and shorter patients show significantly increased in-hospital risk, but no significantly increased one-year risk, even though one-year mortality is cumulative. While we could reasonably expect risk factors affecting in-hospital mortality to affect one-year mortality, simply due to the latter's cumulative nature, these findings are not unreasonable. Note that deaths occurring outside the hospital within one year are not necessarily related to the surgery itself, and could be due to any kind of factor. Furthermore, an emergent presentation can easily be thought of as something that effects the immediate outcome of surgery, but once dealt with, is not something that would affect a patient's discharge status if alive; in other words, if a patient does survive the immediate risks posed by an emergent presentation, that patient is then no different from others post-discharge. Similar arguments can be made for the diabetes and height variables. While diabetic and shorter patients present operative difficulties, these conditions pose little risk once the operation is successful. The noise resulting from random deaths outside of the hospital dilutes the statistical power these variables had from their inpatient predictive ability.

The key finding from the one-year cumulative mortality logistic analysis is that there is no significant evidence of a time trend among the pooled group of patients for whom there are complete one-year follow-up data. Also, controlling for pre-operative risk factors, mortality is significantly higher at Hospital A than at the referent hospital with the lowest one-year mortality, Hospital C. Congestive heart failure and renal insufficiency contribute greatly to

one-year mortality risks, as do being over 80 years old and having undergone CABG surgery previously. Patients with higher ejection fractions were less likely to die within one year, which is consistent with the inpatient results.

7.6.3.4 Regression Results: Within-Site One-Year Mortality

Just as in the case of inpatient mortality, the possibility of a site-specific time trend in one-year mortality demanded that regressions be run for each hospital, individually. The risk factors used as independent variables are those appearing in Model 6 (i.e., the most significant variables from the full one-year mortality model). The sample sizes for these regressions are even smaller than those in the inpatient site-specific models, because patients undergoing surgery after December 1992 are excluded, making inferences even more difficult to draw.

The results are reported in Table 7-22. The time trend results are similar to those seen in the inpatient analysis. Hospital A's regression shows a significant downward trend in one-year mortality, with an odds ratio of .94 (p=.09). This time trend is less significant than that for Hospital A's inpatient mortality regression, but there were far fewer observations for the one-year regression (N=330, compared to N=544). Again, the time trend odds ratio is interpreted in monthly units; scaled to one year, the odds ratio becomes .48, meaning that a patient undergoing surgery one year later is estimated to be less than half as likely to die within a year of surgery. The time trend variable is not significant for any other hospital-specific regression.

Congestive heart failure adds significantly to one-year mortality risk at all sites but Hospital D, which had only 164 observations, and no significant variables. While some of CHF's p-values are relatively weak (p=.08 for Hospital A, p=.06 for Hospital C), these would almost certainly improve with larger samples. Renal insufficiency is a notably strong risk factor at Hospital A, even with this small sample (odds ratio = 6.05, P<.01). The renal variable was not as strong at Hospital B (odds ratio = 2.12, p=.08), and not quite significant at C (odds ratio = 3.72, p=.11).

Patients aged 80 and above at Hospital A are estimated to be nearly five times as likely to die within one year as patients under 80 (odds ratio 4.94, p<.01) The AGE 80+ variable was excluded from the Hospital D regression due to convergence problems.

Previous CABG, significant in all four inpatient within-site regressions, is significant in the within-hospital models only at Hospitals B and C. IABP is significant at B and C as well.

A higher ejection fraction is significantly associated with a lower one-year mortality risk only at Hospital B, the site with the largest sample size (N=909). It comes close to significance at Hospital A(p=.15) and D(p=.10).

TABLE 7-22

WITHIN-SITE CUMULATIVE ONE-YEAR MORTALITY LOGISTICS

	Hospital A		Hospital B		Hospital C		Hospital D	
VARIABLE	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCPT	.31	.20	.29 **	.04	.01 ***	.00	.23	.39
TREND	.94 *	.09	.99	.68	1.03	.59	1.06	.45
CHF	2.11 *	.08	2.08 **	.03	4.03 *	.06	4.60	.13
RENAL	6.05 ***	.00	2.12 *	.08	3.72	.11	.71	.79
AGE 80+	4.94 ***	.00	1.82	.16	1.25	.80	N/A	N/A
PREVIOUS CABG	1.66	.47	2.67 **	.01	12.70 ***	.00	2.86	.49
IABP	1.96	.26	3.85 **	.02	99.22 ***	.00	.96	.97
EJECTION FRACTION	.98	.15	.97 ***	.00	1.01	.64	.96	.10
NO. OBSERVATIONS	330		909		388		164	
OVERALL CLI-SQUARE	35.0	.0001	44.8	.0001	37.2	.0001	10.7	.10

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992. Information on one-year mortality is from the Medicare Enrollment files, 1991-1993.

The key findings with regard to one-year mortality at the individual hospital level is that there is no evidence of an upward trend in one-year mortality at any of the four original demonstration sites, controlling for those risk factors with the greatest predictive power. Hospital A shows a significant and quantitatively large decrease in one-year mortality, just as it did with inpatient mortality.

7.6.4 Regression Results: Inpatient Mortality Including Complications

7.6.4.1 Inpatient Mortality Including Complications

The general inpatient mortality model (Model 3 of Table 7-16) includes only pre-operative risk variables because of the priority placed on an unbiased trend coefficient. The odds ratios from this model, while useful as estimates of relative risk from surgery *ex ante*, are biased in the absence of post-operative complications in the model. For example, patients suffering a particular comorbid illness prior to surgery may be more likely to suffer a particular post-operative complication. If inpatient death is closely associated with the occurrence of this complication, then the effect of this complication will be reflected in the odds ratio for the comorbid illness, overstating its direct effect on mortality risk. To obtain unbiased estimates of the relative risks posed by the comorbid illnesses themselves, independent of possible complications and also to assess the relative risks posed by post-operative complications, we add these complications to our logistic mortality model. The trend variable in this expanded model, however, is not itself to be interpreted as a true representation of the effect of the demonstration on mortality outcomes to the extent complications are under then providers' control and possibly an adverse outcome. The hospital dummy variables are similarly biased. If, on the other hand, complications are outside the providers' control as well, then controlling for them gives a truer picture of demonstration effects.

Table 7-23 reports the results from three logistic regressions. The first column is the same model reported in Model 3 of Table 7-16, with a (0,1) dependent variable indicating whether a patient died in-hospital, and pre-operative risk factors as independent variables. It is replicated here so that its odds ratios can be directly compared with their counterparts in the model including post-operative variables. The second regression, Model 8, has the same dependent variable, but adds a set of post-operative complications to the list of independent variables. The third regression, Model 9, uses the pre-operative independent variables, and has a (0,1) dependent variable indicating whether any post-operative complication occurred following surgery. A *priori*, we expect that where a variable is significant in Model 3, that variable is coefficient will change substantially from the first to the second regression due to an association with post-operative complications raising the likelihood of death.

TABLE 7-23

POOLED INPATIENT MORTALITY LOGISTIC RESULTS USING PRE- AND POST-OPERATIVE RISK FACTORS, LOGISTIC RESULTS ON COMPLICATIONS

	Model 3 Inpatient Mortality Pre-op		Model 8 Inpatient Mortality Pre- and Post-op		Model 9 Complication	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	1.18	0.93	0.35	0.68	0.30 *	0.06
HOSPITAL B	1.27	0.47	1.48	0.34	0.27 ***	0.00
HOSPITAL A	0.96	0.91	0.78	0.55	0.31 ***	0.00
HOSPITAL D	1.33	0.47	0.18 ***	0.01	0.37 ***	0.00
TREND	0.99	0.21	0.97 **	0.03	1.01 *	0.07
URGENT	1.65	0.10	1.04	0.91	0.97	0.82
EMERGENT	2.63 ***	0.00	1.63	0.13	1.37 **	0.02
UNSTABLE	1.55	0.12	2.72 ***	0.00	0.95	0.68
MIZWEEK	1.41	0.28	2.13 *	0.06	1.11	0.44
PREVIOUS CABG	4.58 ***	0.00	2.10 **	0.02	1.60 ***	0.00
DRG 106	1.44 *	0.08	1.61 *	0.05	1.39 ***	0.00
CHF	1.35	0.21	1.13	0.66	1.55 ***	0.00
DIABETES	1.66 **	0.01	1.53 *	0.09	0.98	0.85
RENAL	2.29 ***	0.00	1.85 **	0.03	1.33 **	0.03
COPD	1.62 **	0.04	1.89 **	0.02	1.36 ***	0.01
STROKE	1.18	0.56	1.57	0.16	1.27 *	0.09
HYPER	1.18	0.42	1.20	0.47	1.19 *	0.05
AGE 65-69	0.90	0.77	1.06	0.91	0.87	0.36
AGE 70-74	1.29	0.49	1.58	0.32	1.07	0.65
AGE 75-79	1.91 *	0.09	2.43 *	0.06	1.30	0.12
AGE 80+	2.39 **	0.04	2.14	0.15	1.67 **	0.01
FEMALE	1.12	0.66	1.29	0.41	0.98	0.86
HEIGHT	0.10 **	0.03	0.10 *	0.08	1.57	0.17
IABP	3.01 ***	0.00	3.75 ***	0.00	1.82 **	0.01
ARTERY70	1.01	0.97	0.75 *	0.07	1.09	0.13
LMCA	1.13	0.57	2.90 ***	0.00	0.87	0.17
EJECTION FRACTION	0.97 ***	0.00	0.98 **	0.01	1.00	0.32
BLOODUSE	-	-	1.02 ***	0.00	-	-
REVASC. INDEX	-	-	0.69 **	0.02	-	-
REOP FOR BLEEDING	-	-	3.21 **	0.05	-	-
REOP FOR OTHER	-	-	1.77	0.18	-	-
AMI COMPLICATION	-	-	1.98	0.34	-	-
INFECTION COMPLICATION	-	-	1.70	0.12	-	-
STROKE COMPLICATION	-	-	3.19 ***	0.00	-	-
PULMONARY COMPLICATION	-	-	1.89 **	0.02	-	-
RENAL COMPLICATION	-	-	8.20 ***	0.00	-	-
VASCULAR COMPLICATION	-	-	3.20 *	0.07	-	-
No. Observations	2,920		2,808		2,917	
Overall Chi-Square	162.6	0.0001	295.2	0.0001	319.9	0.0001

NOTE: The dependent variable for the first two regressions is a dichotomous variable equaling 1 if in-hospital death occurred. The dependent variable in the third regression equals 1 if the patient had any post-operative complication.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1993. Information on one-year mortality is from the Medicare Enrollment files, 1991-1993.

heart\tables\TAB7-23.XLS\ind

Several of the post-operative variables in Model 8 are highly significant, and add greatly to the risks of mortality. The number of blood units used is highly significant, with an odds ratio of 1.01 per unit ($p<.01$). Like those for other continuous variables, the odds ration for blood use is scaled to estimate the relative risk associated with a change of one unit. Scaled to estimate the relative risk associated with the use of 10 additional blood units, the odds ratio is 1.16. Not surprisingly, a higher revascularization index is associated with greatly reduced mortality risk.

Post-operative complications contribute substantially to inpatient mortality risk. Reoperation for bleeding, stroke complication, and vascular complication are all associated with significant relative mortality risks about three times as great as those faced by patients not suffering these complications. Renal complications in particular have a large effect on mortality risk, with an odds ratio of 8.20 ($p=.01$). Pulmonary complications involve a relatively modest increase in risk, with an odds ratio of 1.89 ($p=.02$). Notably, a post-operative AMI involves no significant increase in mortality risk, possibly be due to the low incidence of post-operative AMI among these patients (about 1.2 percent).

Model 8 suggests a downward trend in mortality during the demonstration period (odds ratio = .97, $p<.05$), but as noted earlier, the inclusion of post-operative complications in this model may bias the trend variable. The significant negative mortality trend in Model 8 still could be consistent with a diminution in hospital performance if post-operative complications are the result of demonstration-initiated behaviors.

Examination of the trend variable in Model 9 helps make this clear. When the dependent variable represents the presence of a complication following surgery (rather than inpatient mortality), we see a significant ($p=.07$) upward trend, meaning more complications occur later in the demonstration.

Thus, there appears to be two separate trend effects at work with regard to inpatient mortality: (1) an increase over time in post-operative complications that often lead to death; offset by (2) a decrease in inpatient mortality over time, controlling for post-operative complications. The net effect, illustrated in Model 3, is no significant time trend in inpatient mortality, absent any controls for complications.

Like the trend, the hospital dummy variables in Model 8 are affected by the inclusion of the post-operative variables. While no hospital dummy variables were significant in Model 3, controlling for both pre-operative and post operative risk factors causes Hospital D to show significantly lower risks of mortality (odds ratio = .18, $p<.01$) than the referent, Hospital C. Taken by itself, however, this result may be misleading. Since post-operative complications are controlled for in this model, the hospital dummy variables could be biased towards lower mortality.

Again, changes in the pre-operative variable odds ratios from Model 3 to Model 8 reflect correlations between these and the complications variables. From Model 3, we infer that emergent cases are 2.63 times more likely to die in-hospital, but with the post-operative variables in Model 8, the emergent odds ratio appears smaller and is statistically insignificant. From this, we conclude that emergent patients are more likely than others to suffer deadly complications. This notion is validated by an examination of Model 9: the emergent variable odds ratio is 1.37, p=.02. A similar story can be told for patients over 80 years old and patients who have previously undergone CABG surgery. The AGE80+ and PREVCABG variables both have large, significant odds ratios in the pre-operative model, but smaller, less-significant odds ratios in the pre-op/post-op model; AGE80+ went from 2.39 (p<.04) to an insignificant result, PREVCABG went from 4.58 (p<.01) to 2.10 (p<.02). Both these groups of patients are shown in Model 6 to suffer significantly more complications than others.

This pattern does not hold for all the pre-operative risk factors, however. While all the comorbid illness variables except diabetes significantly increase the risk of suffering a complication, this fact does not appear to greatly impact the estimates of relative risk for these variables when complications are controlled for. And the large increase in mortality risk associated with IABP use does not disappear with the addition of the complication variables, despite IABP's large and significant odds ratio in the complications regression (1.82, p=.01).

The pre-operative odds ratios reported in Model 8 are, in one sense, more accurate estimates of the true relative mortality risks directly associated with those particular risk factors than their counterparts in Model 3. The inclusion of post-operative complications in the model separates out the effects of the pre-operative risk factors from those of the post-operative complications with which they are correlated. The pre-operative odds ratios in Model 3, however, do serve as valuable *ex ante* estimates of the relative risks of CABG surgery for patients characterized with these conditions.

Model 9 shows an important finding with regard to hospital differences in complications. Controlling for pre-operative patient risk factors, Hospital B, A and D all show significantly lower complication risks than the referent, Hospital C. The magnitude of these differences is large: B's odds ratio is .27, A's is .31, and D's .37 (all p<.01). It is important to note, however, that Hospital C's high relative complication rate does not involve a significantly higher mortality rate, as all Hospital dummy variable in Model 3 are insignificant.

7.6.4.2 Regression Results: Cumulative One-Year Mortality Including Complications

Table 7-24 presents the results of the one-year mortality models, and steps in the post-operative complications. Model 9 in this table is the same complication model discussed in the previous section, Model 5 is the same full one-year mortality table appearing in Table 7-21.

The trend variable in the one-year mortality model, which may be biased downward when complications are controlled for, follows a pattern similar to that seen in the inpatient mortality analysis. Model 10, the one which controls for complications, shows a significant downward trend in mortality (odds ratio = .95, $p<.05$); a patient undergoing surgery a year later during the demonstration has an estimated risk of one-year mortality only 54 percent as great as an earlier patient. But as noted earlier, Model 9 shows an upward trend in the complications rate itself, and the net result is an insignificant time trend in one-year mortality, as illustrated in Model 5 (odds ratio = .99, $p=.48$). If complications are unrelated to provider behaviors under the demonstration, then controlling for them gives a more accurate measure of one-year mortality trends.

The relatively high one-year mortality rates at Hospitals A and B, reported in Model 5 and discussed earlier in Table 7-13, appears largely unaffected by the inclusion of the complications variables. Even with controls made for potentially serious post-operative complications, demonstration patients treated in these two hospitals were (statistically) significantly more likely to die within a year of surgery compared with Hospital C. Hospital B patients are 2.6 times more likely to die while Hospital A patients are over 4 times more likely to die.

Not surprisingly, the one-year mortality model is less sensitive in general to the inclusion of post-operative complications than was the inpatient model. The coefficients in the pre-operative risk model did not change much after post-operative variables were added. Of the two outcomes, inpatient mortality would clearly be thought of as the one more closely related to complications, since one-year mortality includes a far greater random element. The only pre-operative variable significant in Model 5 but not significant in Model 10 is previous CABG, which went from 3.18 ($p<.01$) to 1.74 ($p=.15$).

Higher numbers of blood units used are significantly related to higher one-year mortality risks, and a higher revascularization index is significantly related to a lower one-year mortality risk. Both of these parameter estimates are of a magnitude similar to those in the inpatient analysis. Fewer of the post-operative complications, so highly significant in the inpatient mortality model, are significantly related to one-year mortality, however. Stroke and renal complications are still associated with significant increases in mortality risk, but pulmonary and vascular complications are no longer significant. And where inpatient

TABLE 7-24

POOLED CUMULATIVE ONE-YEAR MORTALITY LOGISTIC RESULTS USING PRE- AND POST-OPERATIVE RISK FACTORS, LOGISTIC RESULTS ON COMPLICATIONS

	Model 5* Full One-Year Mortality Pre-Op		Model 10 One-Year Mortality Pre- and Post-Op		Model 9 Complication	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	.41	.70	0.18	0.50	0.30 *	0.06
HOSPITAL B	2.26 **	.04	2.59 **	0.05	0.27 ***	0.00
HOSPITAL A	3.09 ***	.00	4.01 ***	0.00	0.31 ***	0.00
HOSPITAL D	1.94	.20	0.52	0.39	0.37 ***	0.00
TREND	.99	.48	0.95 **	0.03	1.01 *	0.07
URGENT	1.16	.64	0.82	0.61	0.97	0.82
EMERGENT	1.44	.26	0.78	0.53	1.37 **	0.02
UNSTABLE	1.01	.97	1.42	0.29	0.95	0.68
MI2WEEK	1.20	.60	1.50	0.30	1.11	0.44
PREVIOUS CABG	3.18 ***	.00	1.74	0.15	1.60 ***	0.00
DRG 106	1.28	.27	1.25	0.38	1.39 ***	0.00
CHF	2.02 ***	.01	1.95 **	0.02	1.55 ***	0.00
DIABETES	1.06	.82	0.81	0.47	0.98	0.85
RENAL	2.18 **	.01	2.02 *	0.05	1.33 **	0.03
COPD	1.50	.12	1.70 *	0.06	1.36 ***	0.01
STROKE	1.28	.46	1.48	0.29	1.27 *	0.09
HYPER	1.23	.36	1.42	0.17	1.19 *	0.05
AGE 65-69	.66	.28	0.59	0.22	0.87	0.36
AGE 70-74	.74	.40	0.56	0.16	1.07	0.65
AGE 75-79	.94	.86	0.76	0.52	1.30	0.12
AGE 80+	1.81	.17	1.41	0.48	1.67 **	0.01
FEMALE	.86	.59	0.87	0.67	0.98	0.86
HEIGHT	.28	.31	0.36	0.45	1.57	0.17
IABP	2.50 **	.02	2.49 *	0.05	1.82 **	0.01
ARTERY70	1.17	.26	1.02	0.91	1.09	0.13
LMCA	.86	.57	1.97	0.13	0.87	0.17
EJECTION FRACTION	.98 ***	.01	0.98 **	0.02	1.00	0.32
BLOODUSE	-	-	1.01 ***	0.00	-	-
REVASC. INDEX	-	-	0.72 *	0.05	-	-
REOP FOR BLEEDING	-	-	0.70	0.60	-	-
REOP FOR OTHER	-	-	2.75 **	0.02	-	-
AMI COMPLICATION	-	-	0.89	0.88	-	-
INFECTION COMPLICATION	-	-	1.54	0.37	-	-
STROKE COMPLICATION	-	-	2.04 *	0.08	-	-
PULMONARY COMPLICATION	-	-	1.50	0.19	-	-
RENAL COMPLICATION	-	-	11.46 ***	0.00	-	-
VASCULAR COMPLICATION	-	-	0.70	0.76	-	-
No. Observations	1,577		1,533		2,917	
Overall Chi-Square	101.3	.0001	169.6	.0001	319.9	.0001

NOTE: The dependent variable for the first two regression B a dichotomous variable equaling 1 if a patient died within one year following CABG surgery. The dependent variable in the third regression equals 1 if the patient had any post-operative complications.

* Coefficients taken from Table 7-21.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1993. Information on one-year mortality is from the Medicare Enrollment files, 1991-1993.

mortality risk was significantly increased by reoperation for bleeding, one-year mortality risk is significantly increased by reoperation for other reasons.

In summary, the key finding is that the inclusion of post-operative complications variables results in a significant downward time trend. If complications are unrelated to provider behavior under the demonstration (i.e., if the observed upward trend in complications is not the result of poorer performance due to bundled payments), then this apparent downward trend in mortality is an accurate estimate of the actual trend in mortality. If, however, the increase in complications over time is interpreted as a result of the demonstration, then the pre-operative model represents the more accurate time trend estimate, and we would conclude that there was no significant trend in mortality over the period of the demonstration.

7.6.5 Regression Results: Trends in Inpatient Lengths of Stay

Table 7-25 presents regression results explaining differences in patient total and post-operative lengths of stay among the four original demonstration hospitals and across time, controlling for patient demographics, comorbid conditions, disease anatomy, complications, and inpatient death. All DRG 106 and 107 patients are pooled in a single regression with a dummy shift variable (DRG 106). Hospitals C, A, and D are represented by dummy variables as well, with hospital B (and other under-65 uncomplicated patients) included in the intercept.

In Model 11, only the hospital the patient was treated in and the month (embedded in the TREND variable) are controlled for. The results indicate that all three hospitals in the model had significantly longer lengths of stay than hospital B, which is consistent with earlier descriptive tables. Hospital C's stays were 1.43 days longer than hospital B; A's stays were 2.02 days longer; and D's stays were 5.19 days longer.

The monthly trend coefficient, equal to -0.08, implies that patients discharged ten months after the beginning of the demonstration had average stays that were .8 days shorter than those discharged in the demonstration's first month. Extended across the full period of our clinical data base from June 1991 through December 1993, i.e., roughly 30 months, the average reduction in lengths of stay across all demonstration hospitals was 2.4 days. This trend is highly significant.

In Model 12, DRG and other patient characteristics are controlled for, but not complications. Controlling for DRG mix and patient characteristics greatly narrows the differences in hospital lengths of stay but does not eliminate them for hospitals' A and D versus hospital B. Roughly one day of the difference is explained between B and the other three hospitals. Lengths of stay are no longer significant between hospitals' B and C; the difference between B and A is reduced to 1.13 days (still highly significant); and between B and

TABLE 7-25

OLS REGRESSION RESULTS: TOTAL AND POST OPERATIVE LENGTH OF STAY

	TOTAL LENGTH OF STAY						Post-Operative Length of Stay	
	Model 11		Model 12		Model 13		Model 14	
Variable	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
INTERCEPT (B)	10.54 ***	.00	7.03 **	.00	8.87 **	.00	7.24 **	.00
HOSPITAL C	1.43 ***	.00	0.43	.23	0.41	.18	0.24	.37
HOSPITAL A	2.02 ***	.00	1.13 **	.00	1.44 **	.00	0.64 **	.02
HOSPITAL D	5.19 ***	.00	4.59 **	.00	3.80 **	.00	2.25 **	.00
TREND	-0.08 ***	.00	-0.11 **	.00	-0.12 **	.00	-0.10 **	.00
URGENT	-	-	1.30 **	.00	1.15 **	.00	0.21	.38
EMERGENT	-	-	-0.59 *	.10	-1.05 **	.00	0.27	.31
UNSTABLE	-	-	-0.23	.42	0.07	.78	0.10	.63
MI2WEEK	-	-	0.51	.13	0.60 **	.04	0.40	.11
PREVCABG	-	-	1.15 **	.00	0.59 *	.08	0.07	.81
DRG 106	-	-	2.31 **	.00	2.17 **	.00	0.03	.89
CHF	-	-	1.93 **	.00	1.68 **	.00	0.81 **	.00
DIABETES	-	-	0.57 **	.02	0.38 *	.07	0.34 *	.06
RENAL	-	-	1.57 **	.00	1.30 **	.00	0.73 **	.00
COPD	-	-	0.80 **	.00	0.50 **	.04	0.27	.20
STROKE	-	-	0.98 **	.01	0.55 *	.08	0.38	.16
HYPER	-	-	0.65 **	.00	0.35 *	.07	0.16	.33
AGE 65-69	-	-	0.69 *	.08	0.49	.15	0.50 *	.09
AGE 70-74	-	-	0.95 **	.02	0.71 **	.04	0.77 **	.01
AGE 75-79	-	-	1.50 **	.00	1.15 **	.00	1.78 **	.00
AGE 80+	-	-	2.10 **	.00	1.57 **	.00	1.55 **	.00
FEMALE	-	-	0.71 **	.01	0.80 **	.00	0.57 **	.00
HEIGHT	-	-	0.69	.41	-0.58	.41	-0.17	.78
IABP	-	-	-0.20	.76	0.40	.48	0.04	.93
ARTERY70	-	-	0.22	.11	-0.01	.97	-0.08	.46
LMCA	-	-	-0.63 **	.01	-0.29	.40	-0.26	.38
EJECTION FRACTION	-	-	-0.02 *	.05	-0.02 **	.01	-0.02 **	.03
BLOOD USE	-	-	-	-	0.01 **	.00	0.01 **	.00
REVASCULARIZATION INDEX	-	-	-	-	-0.05	.66	-0.01	.93
REOP FOR BLEEDING	-	-	-	-	-1.67 **	.03	-1.52 **	.03
REOP FOR OTHER	-	-	-	-	3.37 **	.00	3.40 **	.00
POST-OP AMI	-	-	-	-	0.38	.62	0.65	.34
INFECT COMPLICATION	-	-	-	-	5.37 **	.00	5.34 **	.00
STROKE COMPLICATION	-	-	-	-	4.70 **	.00	4.80 **	.00
PULMONARY COMPLICATION	-	-	-	-	4.33 **	.00	4.10 **	.00
RENAL COMPLICATION	-	-	-	-	2.80 **	.00	2.55 **	.00
VASCULAR COMPLICATION	-	-	-	-	0.73	.48	1.45	.11
INPATIENT DEATH	-	-	-	-	-5.19 **	.00	-5.23 **	.00
R-Squared	.08		.20		.40		0.35	
Observations	3,495		2,858		2,752		2,752	
Mean	10.40 days							

NOTE *** = significant at 1% level
** = significant at 5% level
* = significant at 10% level

SOURCE Abstracts of clinical records from the demonstration hospitals, May 1991 through December 1992

D to 4.59 days (highly significant). Controlling for patient characteristics and DRG actually raises the trend coefficient by over one-third (to -0.11), implying that factors in the hospitals' case mix leading to longer stays became more frequent over the demonstration period. When multiplied by 30 months, the point estimate of the case mix-adjusted length of stay fell by 3.3 days.

Compared to DRG 107, DRG 106 patients remained hospitalized 2.31 days longer, even after controlling for patient demographics, comorbid conditions, and disease anatomy. All six comorbid conditions added to stays relative to less complicated patients. Congestive heart failure added nearly 2 days on average while renal failure added 1.57 extra days. The other four comorbid conditions added a half to a full day of extra care.

Compared to the under-65 Medicare eligibles, all elderly patients experienced longer stays. Length of stay rose monotonically with age with patients over 80 staying 2.1 days longer, *ceteris paribus*. Females stayed 0.41 days longer as well, regardless of age.

Patients admitted as urgent stayed 1.1 days longer, but emergent cases actually had stays that were over half a day shorter on average. Whether the patient had unstable angina upon admission or had had an MI within the two weeks before admission did not appear to be significantly related to stays. On the other hand, if a patient had had a previous bypass, their stay was prolonged by 1.15 days on average.

Two variables describing disease anatomy and severity were found to be important factors in having shorter stays. Patients with significant left main artery disease (over 50 percent stenosis) averaged 0.63 shorter stays as did those with higher ejection fractions, possibly due to less severe overall stenosis. *Ceteris paribus*, a patient with an ejection fraction of only 30 percent had a one day longer stay than a comparable patient with a fraction equal to 80 percent.

Controlling for patient demographics, comorbid disease, clinical presentation, and disease anatomy increased the equation's explanatory power from 8 percent to 20 percent. This reflects the fact that variations in patient lengths of stay depend more on individual patient characteristics than in which hospital or in which month of the demonstration a patient was treated in.

Model 12 only controls for those characteristics that precede the bypass surgery and are assumed to be unaffected by provider behavior. In Model 13, complications related to the bypass surgery, blood use, and the completeness of revascularization are further controlled for. As expected, these variables double the explanatory power of the model compared with just controlling for pre-operative factors. Eight of the eleven additional variables were found to be highly significant; only the revascularization index, whether the patient had a post-operative MI, and any vascular complication did not seem to add to stays. Infections, strokes, and

pulmonary complications added 4.3 to 5.3 days to the average stay, followed by reoperation for reasons other than bleeding or renal complications (roughly 3 days more). The negative impact of reoperations for bleeding on stays is unexplained.

Patients dying in the hospital after bypass surgery had much shorter stays, 5.2 days less than survivors. Most likely, average stays for patients who die in the hospital exhibit a bimodal distribution with some having short and others very long stays. The large negative coefficient, however, is interpreted as the impact of dying on length of stay after controlling for comorbid disease, age, and other complications. That is, Model 13 effectively factors out the long-stay group of nonsurvivors, leaving the death coefficient to reflect those patients who die soon after surgery.

If one assumes that all complications are unrelated to the quality of care received in any hospital, they can be interpreted as additional controls for case mix severity across demonstration hospitals. Comparing the hospital coefficients for Models 12 and 13 shows relatively little change. Average lengths of stay in both hospitals A and D remain significantly longer than in hospital B (in the intercept). The difference between hospital A and B becomes a third of a day longer while the difference narrows by .8 days between hospital D and B.

Controlling for complications, death, and revascularization raises the intercept by almost 2 days. This implies that the relatively short stays experienced in hospital B are due to a relative infrequency of complications in the institution. Assuming complications are independent of patient care, this suggests a simpler bypass case mix in hospital B[3]. Alternatively, fewer complications may be due to higher quality care.

Controlling for complications, the time trend coefficient becomes slightly more negative, implying even greater reductions in lengths of stay once intertemporal differences in complication rates are held constant.

Complications almost always extend a patient's stay. Thus, controlling for them in Model 13 should reduce the size of other positive coefficients that are associated with complications, and vice-versa, if they are negative. For example, the length of stay coefficients for the comorbid conditions are all reduced, some by almost 50 percent, when complications are controlled for, implying that patients with multiple diseases are more likely to experience post-operative complications and stay longer. On the other hand, comorbid disease patients are also more likely to die in the hospital (correlation coefficients with death are positive), which should raise their effects on length of stay if discharge status is not controlled for. The fact that the coefficients for the comorbid diseases fall when complications and death are

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[3] The hospital's overall Medicare casemix index exceeds 2.0, reflecting the disproportionate number of hi-tech procedure cases.

included implies that, overall, the comorbid diseases lengthen stays in spite of shortening stays significantly for the few patients who die in the hospital. The same argument is true for patients undergoing their second CABG. Very similar effects are observed for patient age, i.e., greater age has less of an effect in prolonging stays once complications are controlled for.

Of course, if complications are assumed to be the result of the care received while hospitalized, then controlling for them would be inappropriate in evaluating hospital differences and trends in lengths of stay. If, for example, one hospital exhibited a relatively long stay that disappeared once its high complication rate was accounted for, it would be wrong to conclude it did not have, in fact, a longer-than-average stay. As it turns out, controlling for complication rates does not alter the basic conclusions of Model 13, which are (a) hospitals B (and likely C) have lower overall lengths of stay than hospitals' A and D controlling for case mix severity, and (b) the downward trend in length of stay is unrelated to changes in the complication rates.

Model 14 presents results on a narrower definition of stays; namely, the time between surgery and discharge. Prior expectations are that pre-operative variables should be far less important while post-operative complications should increase in relative importance, if not in absolute value. This hypothesis is borne out in the comparison of Model 14 with Model 13. Many of the variables found to be significant in explaining total stays are unrelated to stays in the post-operative period. These include such variables as urgent/emergent status, DRG, COPD and previous stroke, and having a previous CABG. Conversely, patient age, ejection fraction, and the complication coefficients are hardly affected, implying that their impacts are being felt primarily in the post-operative period. Post-operative stays average roughly two-thirds of a patient's total stay on average. Hence, variables with similar coefficients in Models 13 and 14 have roughly a 33-50 percent greater impact on post-operative versus total stays depending upon which denominator is used. Patients over 80, for example, stay 1.5 days longer than average, *ceteris paribus*. This adds approximately 14 percent to a 10.4 day average total stay versus 21 percent to the post-operative period in the hospital.

Comparing the hospital coefficients for Models 13 and 14 isolate the source of the difference in longer stays. As with total stays, post-operative lengths of stay do not differ between hospitals B and C. When the short-stay hospital B is compared to A by segment of the stay, the 1.44 day difference in average total stays is found to be made up by a 0.64-day portion after the bypass operation and a .80-day portion (= 1.44 - .64) prior to the operation, holding DRG mix and many other factors constant. In other words, the longer stays in hospital A relative to B are due 55 percent to pre-surgical days and 45 percent to post-surgical days. Hospital D's 3.8 day average total stay difference can be similarly decomposed into a 2.25-day difference post-surgery vs. a 1.55-day difference pre-operatively, or 41 percent pre-operatively

and 59 percent post-operatively. Although similar decompositions could be done using the descriptive tables presented earlier in the chapter, they controlled only for DRG and not any other case mix differences across institutions.

Model 14 also provides information on the decline in post-operative portions of patient stays. The negative trend coefficient of -0.10 implies that after thirty months in the demonstration, the "average" patient discharged in December of 1993 experienced a 3-day shorter post-operative stay compared with similar patients discharged in the demonstration's first month in June 1991, holding other factors constant. The decline in overall stays from Model 13 is estimated to be 3.6 days. Thus, roughly 80 percent of the reduction in overall average stays has come from shortening the time between bypass surgery and discharge.

8.0 IMPACT OF BUNDLED PAYMENTS ON THE APPROPRIATENESS OF CABG SURGERY

8.1 Background and Rationale for Examining Appropriateness

Marked geographic variations in the rates of CABG surgery suggest either excessive use of the procedure in some regions of the country or underservice of other regions. The absence of convincing evidence that higher CABG surgery rates reflect higher prevalence rates of coronary artery disease lend support to the former hypothesis. (For a review of the efficiency and risks of CABG surgery, see Leape *et al.*, undated)

This concern has stimulated efforts to develop clinical guidelines(AHA/ACC Task Force Report, 1991) and appropriateness criteria for the use of CABG surgery (RAND, 1986 and 1991). Application of the first set of RAND criteria in randomly selected hospitals in a western state in 1979 - 1982 concluded that 14 percent of procedures were for inappropriate reasons and another 30 percent were for equivocal reasons (Winslow, 1988). Much lower rates of inappropriate or equivocal use (2.4 percent and 7.0 percent, respectively) were found in a recent study in New York (Leape, 1993). An important question raised by the latter study is whether New York is representative of the U.S. as a whole or has lower rates than other states because it is so highly regulated.

A comparison of CABG surgery in Canada and New York offers further insights. This study used two sets of criteria - the U.S. criteria that had been applied earlier in New York and criteria developed by expert panel of Canadian physicians using a RAND-like methodology - to compare the appropriateness of CABG surgery in the previously reported New York population to that of patients in British Columbia and Ontario (McGlynn, 1994). Using U.S. criteria, 9 percent of Canadian operations were performed for uncertain indications and 2.5 percent were inappropriate compared to 7 percent and 2.4 percent, respectively, in New York. Using Canadian criteria, equivalent figures were 11.3 percent and 3.6 percent for Canadian operations and 9.9 percent and 5.5 percent, respectively, in New York. Hence, appropriateness rates were not significantly different.

Canadian criteria, however, appeared to be more stringent than U.S. criteria. For example, as indicated by the fact that 14.9 percent of Canadian operations and 15.4 percent of New York operations were judged to be uncertain or inappropriate by the Canadian criteria compared to only 11.5 percent and 9.4 percent by U.S. criteria. The Canadian physicians who rated the appropriateness of clinical indications for CABG surgery appear to have had a more conservative mindset than their U.S. counterparts.

The rationale for examining the appropriateness of CABG surgery in the Heart Bypass Center Demonstration grew both from concerns about the appropriateness of surgery being performed under the Medicare program in general, and, in particular, about possible adverse effects of incentives created by bundled payments to increase rates of marginally indicated procedures.

8.2 Specific Objectives

Specific objectives are to:

1. Examine the appropriateness of CABG surgery in demonstration hospitals at baseline;

2. Document any changes in the appropriateness of CABG surgery in response to bundled payments;

3. Document differences among hospitals in the appropriateness of CABG surgery and patterns of change during the demonstration and to examine patient, hospital, and market factors that explain these differences.

Baseline estimates provide evidence that hospitals selected to participate in the demonstration were, in fact, adhering to normative standards. Changes during the period of the demonstration may indicate either industry-wide changes in clinical indications for CABG surgery due to changes in technology or practice norms or may reflect the effects of incentives created by bundled payments. Hospital-specific differences in response may reflect internal or market area influences.

8.3 Methods for Rating Appropriateness

The methods used follow closely those developed by the RAND Corporation (Leape *et al.*, 1991; Chassin *et al.*, 1986) . Steps in developing our appropriateness model included: (1) review of published literature on the effectiveness of CABG surgery; (2) development of a matrix of clinical indications; (3) rating of the appropriateness of clinical indications by an expert Technical Advisory Panel; and (4) calculation of appropriateness scores for clinical indications.

8.3.1 Review of the Literature on CABG Surgery

Nearly 700 studies on the effectiveness, risks, and costs of CABG surgery published between 1971 and 1990 were read, abstracted, and synthesized (Leape *et al.*, 1991). This extensive review, coupled with a more targeted review prepared by Lewin/ICF, served as a foundation for developing a matrix of clinical indications for CABG surgery and provided the technical advisory panel with an up-to-date summary of available scientific evidence. In reviewing the literature and developing the list of clinical indications, care was taken to focus on bypass surgery exclusive of other major cardiac procedures.

8.3.2 Clinical Indications for CABG Surgery

Clinical indications for CABG surgery were developed using the patient's clinical presentation, coronary artery disease anatomy, left ventricular ejection fraction (LVEF), anginal level, comorbidity risk, prior medical therapy, and exercise stress test results as defining variables. The goal was that each indication represented a subpopulation of patients with coronary artery disease that was relatively homogeneous with respect to the benefits and risks of treatment.

Indications were organized into chapters according to the clinical presentation: stable angina, unstable angina, acute myocardial infarction, post myocardial infarction, asymptomatic patients with coronary artery disease, near sudden death, complications of PTCA or coronary angiography, and CABG performed in conjunction with valve surgery.

Within each chapter, indications were arrayed according to the:

- extent of coronary artery disease (left main, 3 vessel disease, 2 vessel disease with or without involvement of the left anterior descending artery (LAD), and 1 vessel disease with or without LAD involvement.
- left ventricular ejection fraction categories
- anginal class (I or II NYHA, III or IV NYHA)
- adequacy of prior medical therapy (maximal, less than maximal)
- exercise stress test (ETT) results (negative or minimally positive, strongly positive)
- comorbidity risk (low, moderate, high)

Key definitions underlying clinical indications include:

- Significant coronary artery disease represents a 50 percent or greater reduction in the luminal diameter of left main coronary artery and a 70 percent or greater reduction in the luminal diameter of other coronary arteries.
- Adequate medical therapy includes at least two categories of anti-anginal drugs or one drug and a note in the record that the patient cannot tolerate the others.
- Comorbidity risk from age, sex, and non-cardiac diseases was defined initially by a modified Parsonnet score (Leape, 1991).
- Left ventricular ejection fraction, anginal class, and ETT results from definitions widely used in the medical literature (Leape, 1991).

8.3.3 Technical Advisory Panel

A technical advisory panel of experts in cardiovascular surgery, invasive and non-invasive cardiology, and general internal medicine was formed to provide appropriateness ratings on clinical indications for CABG surgery. The TAP was selected from lists of individuals recommended by their respective specialty societies supplemented by authors of key articles and recommendations from other experts. The goal was to appoint a panel of 6 to 9 members with at least 2 representatives of each discipline. A representative from a payor organization was added at the request of HCFA's Office of Research and Demonstrations. Nine panelists plus a payor representative were selected, but only 8 completed the entire rating process. Two panelists had to withdraw, one because of illness and the other because of a scheduling conflict. The final panel included 3 cardiovascular surgeons, 2 invasive cardiologists, 2 non-invasive cardiologists/internists and a payor representative.

8.3.4 Appropriateness Ratings

Clinical indications were rated using a modified delphi process. First, the literature reviews and clinical indications matrix were mailed to the panel. Panelists were asked to read the reviews and then to rate appropriateness of clinical procedures for an average patient described by each indication. Ratings were on a scale of 1 to 9 in which a 9 indicated that the procedure was extremely appropriate; a rating of 1 indicated that it was extremely inappropriate; and a rating of 5 indicated neutrality or uncertainty. Each patient scenario was rated three times: (1) for CABG surgery if the patient is not candidate for PTCA; (2) for CABG surgery if the patient is a candidate for PTCA; and (3) for PTCA compared to medical therapy.

Appropriateness was defined in terms of the balance between the expected health benefits (longevity and quality of life) and risks compared to the alternative therapy. For example, a rating of 9 indicated a high degree of certainty that the net benefits (benefits minus risks) of CABG surgery greatly exceeded those of the alternative therapy; a rating of 5 indicated either a certainty that benefits equaled risks or considerable uncertainty about the relationship; and a rating of 1 indicated a high degree of certainty that the net benefits of the alternative therapy greatly exceeded those of CABG surgery.

This initial set of ratings was analyzed and distributed during a two day meeting of the panel held in January, 1991. Each panelist received his/her own ratings and the anonymous ratings of other panelists. Group discussion first focused on recently published studies and studies in progress that addressed controversies on the relative merits of CABG surgery and PTCA in patients with 2VD or 3VD; interventions after AMI; and treatment of patients who have experienced a near "sudden death" event. The group felt strongly that appropriateness estimates should be revised in 2-3 years to incorporated the results of ongoing studies.

Discussion then proceeded chapter-by-chapter to consider the reasonableness of the clinical indications and the definitions of clinical factors used to construct them. Several changes were made to the clinical indications and definitions used in the RAND study (Leape, 1991) and during the initial rating round in this study:

LVEF categories were changed to >50, 25-50, and <25 from >35, 15-35, <15.

Unstable angina: (1) the distinction between maximal and less than maximal therapy was eliminated for patients with continuing symptoms; (2) "no symptoms on maximal medical therapy" was changed to "stabilized on medical therapy".

Acute myocardial infarction: the use of thrombolysis was added as a defining characteristic.

Post myocardial infarction: the distinction between transmural and subendocardial infarctions was dropped in patients who are asymptomatic after MI.

Near sudden death: This subgroup generated considerable controversy. The decision was made to eliminate distinctions based on anatomy, LVEF, angina level, and ETT results and to limit ratings to a single indication for patients "without a Q-wave infarction, with any level of angina, anatomy, and LVEF."

Following the discussion of each chapter, clinical indications were re-rated. A total of 828 clinical indications were rated during the second round. Each was rated for the three treatment pairs noted above for a total of 2484 ratings by each panelist.

8.3.5 Calculation of Appropriateness Scores

Methods developed by RAND were used to analyze ratings (Chassin, 1986). The median value of the eight panelists was used as the measure of central tendency for each unique indication, and the mean absolute distance of ratings from the median was used as the measure of dispersion. The degree of agreement among the panelists is a measure of the confidence one can place in median ratings. Agreement (A) is defined by having all ratings within a 3 point spread after the highest and lowest ratings were eliminated. Disagreement (D) is defined by having at least one rating fall in the 1-3 range and one reading in the 7-9 range after the highest and lowest ratings have been eliminated. Intermediate (I) levels of agreement are those between these extremes.

An indication is considered **"appropriate"** if the median rating is 7 to 9; **"equivocal or uncertain"** if it is 4 to 6; or **"inappropriate"** if it is 1 to 3. Furthermore, an indication is equivocal if there is disagreement, regardless of the median rating.

The proportion of agreements increased from 22.6 percent in the initial round of ratings to 38.5 percent in the second round. Correspondingly, disagreements fell from 27.1 percent to 15.0 percent. Agreements were least frequent and disagreements most frequent in patients being treated after myocardial infarctions.

The final appropriateness ratings and scores are given in Appendix 8.A.

8.4 Analysis of Appropriateness in the Demonstration

8.4.1 Construction of the Appropriateness Analytic File

Appropriateness scores were assigned to each demonstration patient using four clinical factors. Several assumptions were made with regard to clinical information that was either missing from the clinical database or could not be determined reliably. Appropriateness scores were calculated under two treatment decision scenarios: patient is not a candidate for PTCA, and patient is a candidate for PTCA.

8.4.1.1 Clinical Factors

Clinical presentation Patients were categorized with a presentation of stable angina, unstable angina, AMI, or asymptomatic for the admission during which the CABG surgery was performed.

Anatomic extent of disease Left main disease, 3-vessel disease, 2-vessel with left anterior descending (LAD) involvement, 2-vessel without LAD involvement, 1-vessel with LAD involvement, and 1-vessel without LAD involvement.

Left ventricular ejection fraction Patients were placed in the following groups: ejection fraction less than 25 percent, ejection fraction greater than or equal to 25 percent and less than 50 percent, and ejection fraction greater than or equal to 50 percent.

Comorbidity Risk This was defined using the results from a multivariate logistic regression of a set of comorbid risk dummy variables on in-hospital mortality from the first two years of data for the original four sites. The independent comorbid variables in the model were emergent presentation, congestive heart failure, diabetes, renal insufficiency, age 73-79, age 80 and over, female gender, previous CABG surgery, and pre-operative use of an intra-aortic balloon pump. The mean predicted risk score was approximately .05; a patient was categorized as low risk if his predicted risk was less than or equal to the mean, as moderate risk if his score was greater than the mean but less than or equal to twice the mean, and as high risk if his score was greater than twice the mean.

8.4.1.2 Assumptions

Several variables included in the appropriateness model were not consistently and reliably available in our database, requiring some assumptions regarding patient characteristics. These assumptions are outlined below.

Stable Angina: Angina is broken down in the appropriateness model into the subcategories "patient has severe angina" and "patient has mild or moderate angina," and is given separate treatment. Since our data provide no means of distinguishing degrees of angina severity, all patients categorized with a clinical presentation of stable angina are assumed to have severe angina. This assumption could possibly result in a set of appropriateness scores higher than might otherwise be observed.

Within the purview of severe angina patients, the model is broken down further into the categories "on maximal medical therapy" and "on less than maximal medical therapy." Patients receiving more than two medications were defined as being on maximal medical therapy.

Unstable Angina: This category is broken down in the appropriateness model into the subcategories "persistent symptoms on medical therapy" and "no symptoms on medical therapy." All unstable angina patients were assumed to have persistent symptoms on medical therapy. This assumption further errs on the side of a higher appropriateness score.

Myocardial Infarction: The appropriateness model gives separate treatment to evolving AMIs and post-AMIs (AMI within 21 days). All AMI patients in this analysis are categorized as post-AMI. The model breaks down the post-AMI category further into the subcategories "patient has continuing pain," "patient is asymptomatic with very positive exercise ETT," and "patient is asymptomatic with negative to minimally positive exercise ETT." All patients were assumed to have continuing pain. Again, this assumption would tend to overstate the appropriateness score.

8.4.1.3 Patients Excluded from the Analysis Because of Missing Data

Reasons for exclusions from the appropriateness analysis, overall and by hospital, are presented in Table 8-1. Overall, 909 of 4,158 patients (21.9%) were excluded. Reasons for exclusions were:

- patients were missing data on clinical presentation at the time of the CABG surgery admission;
- patients had stable angina, or were asymptomatic, and were missing ETT results;
- patients were missing data on the extent of disease; and
- patients were missing data on LVEF and not excluded for any of the above reasons.

The proportion of excluded patients ranged from 8% in Hospital D to 66% in Hospital G. Reasons for exclusion also varied widely by hospital. Missing exercise test results, responsible for the exclusion of almost all asymptomatic patients, were the main reason for exclusion in Hospitals B and F. Missing left ventricular ejection fractions were the main reasons for exclusions in Hospitals C and G. Missing information on coronary artery anatomy was a frequent reason for exclusion only in Hospital B.

8.4.1.4 Treatment Decisions

Appropriateness scores were calculated for two treatment scenarios: CABG surgery for a patient who is not a candidate for PTCA, and CABG surgery for a patient who is a candidate for PTCA. The national trend was to broaden indications for PTCA over the period of the

TABLE 8-1

DATA FIELDS RESPONSIBLE FOR MISSING APPROPRIATENESS SCORES, BY HOSPITAL

Missing Variable	Hospital A	B	C	D	E	F	G	Total
Clinical Presentation	14	36	0	1	27	7	1	86
Exercise Test *	21	182	18	1	4	55	18	372
Disease Anatomy	19	167	0	0	14	9	1	239
Ejection Fraction	21	69	115	26	6	0	77	212
Missing Appropriateness Scores	75	454	133	28	51	71	97	909
As Percent of Total N	13%	26%	15%	8%	20%	41%	66%	22%

Note: These numbers represent those missing data fields responsible for the exclusion of a patient record from the appropriateness analysis. They do not necessarily correspond perfectly to the total number of fields for that variable. For example, ejection fraction is missing in the clinical dataset for over twice as many records as the 212 reported here, but many of those records missing ejection fraction were also missing another variable value, such as clinical presentation. See text.

* Exercise test was not a relevant data field for every record. The number reported here represents the number cases in which it was both relevant and missing.

Source: Abstracts of clinical records among the seven demonstration hospitals, May 1991 through December 1993. Appropriateness data are from a panel of experts.

demonstration (1991-1993). Hence, the former of these treatment options becomes increasingly likely over this period. The analysis, however, focuses on the appropriateness scores calculated under the assumption that the patient is not a candidate for PTCA. This produces an upward bias in appropriate scores, but none of the clinical records allowed us to distinguish the two possibilities.

8.4.2 Appropriateness Outcome Measures

Summary measures of CABG surgery appropriateness include the percent of total cases that are appropriate, equivocal, or inappropriate, as well as a mean appropriateness score. The former reflects the RAND methodology and permits comparisons to other published reports. The latter requires the assumption that the 1 to 9 rating scale is a continuous variable. There is no obvious reason that net benefits of CABG surgery (effectiveness minus risk) cannot be characterized as a continuous variable. The mean score, therefore, is a measure of the total net benefits provided to Medicare patients.

8.5 Descriptive Results

8.5.1 Characteristics of Included v. Excluded Patients

Characteristics of included and excluded patients are compared, overall and by hospital, in Table 8-2. Age, sex, and race distributions were not significantly different, but large differences are noted on several variables that define the appropriateness model. Included patients have much higher proportions of patients with:

- unstable angina (50.8% v. 29.6%) and post MI (25.2% v. 18.6%);
- DRG 106 (48.8% v. 19.9%)
- congestive heart failure (14.3% v. 9.1%); and
- LMD (23.5 v. 16.4%) and three vessel disease (47.1% v. 34.5%).

Each of these factors importantly influences the risks and benefits of CABG surgery and, hence, the decision to do surgery. Differences in patterns among hospitals are striking.

The large numbers of excluded patients, differences in the clinical characteristics of included and excluded patients, and differences in patterns among hospital markedly affect appropriateness results. This is particularly true for hospitals with high proportions of excluded patients.

TABLE 8-2

CLINICAL CHARACTERISTICS OF PATIENTS INCLUDED IN THE APPROPRIATENESS ANALYSIS AND THOSE EXCLUDED DUE TO MISSING DATA

	Hospital A		B		C		D		E		F		G		Total	
	INC	MISS	INC	MISS	INC	MISS	INC	MISS	INC	MISS	INC	MISS	INC	MISS	INC	MISS
Age																
Less than 65	7.7	2.7	9.8	8.6	4.5	8.3	14.5	10.7	7.7	5.9	6.9	1.4	0.0	0.0	8.2	6.5
65-74	59.8	62.2	64.9	65.6	66.8	62.4	61.1	64.3	65.2	62.7	63.4	63.4	75.5	69.1	64.3	64.8
75-84	30.6	35.1	24.9	25.6	27.8	27.8	22.3	25.0	26.6	31.4	28.7	33.8	24.5	30.9	26.5	28.2
85 or Older	1.9	0.0	0.4	0.2	0.9	1.5	2.0	0.0	0.5	0.0	1.0	1.4	0.0	0.0	0.9	0.4
Sex																
Male	60.5	70.7	66.5	66.2	69.3	74.4	63.3	71.4	67.1	70.6	70.3	70.4	81.6	69.1	66.3	68.8
Female	39.5	29.3	33.5	33.8	30.7	25.6	36.7	28.6	32.9	29.4	29.7	29.6	18.4	30.9	33.7	31.2
Race																
White	96.3	97.8	96.4	95.4	97.1	96.9	97.4	96.4	86.0	82.4	81.2	81.7	93.8	93.8	95.5	93.7
Non-White	3.7	2.2	3.6	4.6	2.9	3.1	2.6	3.6	14.0	17.6	18.8	18.3	6.3	6.3	4.5	6.3
Clinical Presentation																
Chronic Stable Angina	30.1	45.9	4.1	9.6	53.9	83.5	8.9	11.1	13.0	20.8	67.3	75.0	49.0	33.3	23.8	32.4
Unstable Angina	54.7	34.4	64.1	36.4	26.3	10.5	78.6	85.2	38.2	45.8	12.9	6.3	4.1	19.8	50.8	29.6
AMI	14.4	18.0	31.8	19.6	19.8	6.0	12.5	0.0	48.8	33.3	19.8	7.8	46.9	40.6	25.2	18.6
Asymptomatic	0.8	1.6	0.0	34.4	0.0	0.0	0.0	3.7	0.0	0.0	0.0	10.9	0.0	6.3	0.1	19.3
DRG																
106	42.2	33.3	41.0	17.3	56.4	41.4	65.8	10.7	54.1	33.3	62.4	38.0	57.1	57.3	48.8	19.9
107	61.0	66.7	59.0	82.7	43.6	58.6	34.2	89.3	45.9	66.7	37.6	62.0	42.9	42.7	51.2	80.1

TABLE 8-2 (continued)

CLINICAL CHARACTERISTICS OF PATIENTS INCLUDED IN THE APPROPRIATENESS ANALYSIS AND THOSE EXCLUDED DUE TO MISSING DATA

	Hospital A		B		C		D		E		F		G		Total	
	INC	MISS	INC	MISS	INC	MISS	INC	MISS	INC	MISS	INC	MISS	INC	MISS	INC	MISS
Revascularization Priority																
Elective	75.9	57.4	51.9	90.1	29.1	42.9	37.1	87.9	85.4	96.0	86.1	86.0	67.3	68.0	57.9	76.6
Urgent	20.1	29.3	5.8	0.2	60.4	51.1	54.8	5.0	6.3	2.0	4.0	7.0	28.6	16.5	29.6	14.0
Emergent	4.0	13.3	42.3	9.7	10.4	6.0	8.1	7.1	8.3	2.0	9.9	7.0	4.1	15.5	12.5	9.4
Previous CABG	8.3	10.7	10.1	6.4	9.3	16.9	4.8	12.5	31.4	12.1	11.9	15.5	85.7	46.7	11.6	16.2
Congestive Heart Failure	27.4	17.3	12.1	10.6	11.9	10.5	8.9	3.6	15.5	9.8	14.9	2.8	0.0	0.0	14.3	9.1
Renal Insufficiency	11.2	1.8	15.5	11.5	4.9	5.5	10.0	7.1	10.1	7.8	5.0	4.2	2.0	0.0	11.0	7.9
Diabetes	29.6	31.7	24.9	24.5	30.1	29.0	30.7	39.3	30.4	25.5	28.7	9.9	26.5	24.7	27.9	25.2
Stroke	12.5	14.3	8.6	7.3	8.7	10.7	10.2	14.3	10.1	2.0	7.9	7.0	0.0	0.0	9.5	8.2
Comorbid Risk																
Low	65.8	72.0	72.6	80.6	79.6	74.4	83.7	67.9	59.9	82.4	74.3	77.5	20.4	37.1	72.7	73.8
Medium	20.5	16.0	15.2	13.2	13.8	18.8	8.3	17.9	20.3	7.8	18.8	19.7	44.9	33.0	15.9	16.7
High	13.6	12.0	12.2	6.2	6.6	6.8	8.0	14.3	19.8	9.8	6.9	2.8	34.7	29.9	11.3	9.5
Disease Anatomy																
Left Main	25.0	14.0	25.7	27.6	23.6	3.6	15.3	14.3	27.1	33.3	16.8	5.7	0.0	1.0	23.5	16.4
3-Vessel	50.5	25.6	42.2	36.6	48.7	7.1	51.1	42.9	50.7	50.0	37.6	2.9	91.8	61.5	47.1	34.5
2-Vessel with LAD	16.5	46.5	19.6	20.7	15.9	72.6	23.6	35.7	15.9	6.7	13.9	65.7	4.1	28.1	17.9	34.9
2-Vessel without LAD	3.8	7.0	3.7	4.7	2.3	13.1	1.6	0.0	2.9	6.7	1.0	25.7	0.0	5.2	3.0	7.5
1-Vessel with LAD	2.7	7.0	4.9	7.3	5.9	2.4	6.4	7.1	2.4	0.0	21.8	0.0	4.1	0.0	5.3	4.4
1-Vessel without LAD	1.5	0.0	3.9	3.0	3.6	1.2	1.9	0.0	1.0	3.3	8.9	0.0	0.0	4.2	3.2	2.4
Ejection Fraction																
Less than 25	2.7	4.0	2.2	4.3	0.8	0.0	1	0.0	4.8	12.0	20.8	23.9	6.1	0.0	2.6	6.0
25-49	31.1	32.0	39.6	37.3	69.6	72.5	30.4	0.0	37.2	16.0	18.8	18.3	63.3	42.9	44.1	40.8
50 or Greater	66.2	64.0	58.2	58.4	29.6	27.5	68.7	100.0	58	72.0	60.4	57.7	30.6	57.1	53.3	53.2

Source: Abstracts of clinical records among the seven demonstration hospitals, May 1991 through December 1993.
Appropriateness data are from a panel of experts.

8.5.2 Percent of Appropriate Cases

Table 8-3 presents the distributions of CABG operations between appropriate, equivocal and inappropriate rating categories by hospital and time period. Over the entire period of the demonstration, 72.7% of cases were judged to appropriate if the patient were a candidate for PTCA, and 97.7 % were appropriate if the patient were not a candidate for PTCA. These findings reflect strong preferences for the less invasive PTCA procedure in patients with two or single vessel disease if coronary lesions are suitable for angioplasty.

Marked differences are noted among hospitals. When the patient is not a candidate for PTCA, the proportion of appropriate cases is above 97% in Hospitals A-E but is only 86.5% in Hospital F and 79.5% in Hospital G. Results in the latter two hospitals need to be interpreted with caution, however, because of high rates of excluded cases (41.3% and 66.4%, respectively). Findings are similar if the patient is a candidate for PTCA, but the entire scale is moved downward about 20% in terms of the proportion of appropriate CABG procedures.

No time trend is evident among the initial demonstration sites between 1991 and 1993.

Table 8-4 examines appropriateness according to the patient's clinical presentation for the hospital admission during which CABG surgery was performed. The chronic stable angina group accounts for the largest proportion of equivocal or inappropriate cases whether or not the patient is a candidate for PTCA. The effect is much more dramatic, however, when the patient is a candidate for PTCA. In this case, 20.8% of cases, overall, are performed for equivocal reasons and 4.8% of cases are inappropriate. Corresponding figures range among hospitals from 7.7% to 79.2% for equivocal indications and from 0% to 19.2% inappropriate procedures.

Equivocal or inappropriate CABG operations are infrequent in patients with unstable angina or post-AMI in patients who are not candidates for PTCA. They become much more frequent, however, if the patient is a candidate for PTCA. Part of the reason relates to the less invasive nature of PTCA and its relatively lower risk in these high-risk patients. Overall, 18.1% and 4.2% of procedures, respectively, are performed for equivocal or inappropriate indications in patients with unstable angina; and 37.3% and 1.7%, respectively, in patients who post-AMI. These results vary strikingly among hospitals.

Table 8-5 offers insights into the association between appropriateness of CABG operations and the extent of coronary artery disease. If the patient is not a candidate for PTCA, 98% or more of cases are appropriate if the patient has left-main disease (LMD), three vessel disease, or two vessel disease with involvement of LAD. This proportion falls to 93.8% in two vessel disease without LAD involvement and to 91.9% and 69.9%, respectively, in one vessel disease with and without LAD involvement.

TABLE 8-3

PERCENT APPROPRIATE, EQUIVOCAL AND INAPPROPRIATE BY HOSPITAL BY YEAR

	Hospital							
	A	B	C	D	E	F	G	Total
Patient is Not a PTCA Candidate								
1991 (May-December)								
Appropriate	96.9	99.3	97.0	100.0				98.3
Equivocal	2.3	0.7	3.0	0.0				1.6
Inappropriate	0.8	0.0	0.0	0.0				0.1
Percent Missing Data	5.2	31.1	23.4	9.5				22.9
1992								
Appropriate	99.5	98.6	96.7	99.1				98.3
Equivocal	0.5	1.4	3.3	0.9				1.7
Inappropriate	0.0	0.0	0.0	0.0				0.0
Percent Missing Data	8.7	33.1	16.5	8.2				22.7
1993								
Appropriate	97.1	98.8	98.1	98.5	98.6	86.1	79.6	97.0
Equivocal	2.9	1.2	1.9	1.5	1.4	11.9	20.4	2.9
Inappropriate	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.1
Percent Missing Data	19.7	16.8	9.5	7.7	19.8	41.3	66.4	21.0
Total All Years								
Appropriate	97.9	98.9	97.4	99.0	98.6	86.2	79.5	97.7
Equivocal	1.9	1.2	2.6	1.0	1.5	11.9	20.5	2.3
Inappropnate	0.2	0.0	0.0	0.0	0.0	2.0	0.0	0.1
Percent Missing Data	12.6	26.2	14.6	8.2	19.8	41.3	66.4	21.9
Patient Is a PTCA Candidate								
1991 (May-December)								
Appropriate	73.4	74.6	68.7	85.1				74.2
Equivocal	21.9	21.1	24.4	14.9				21.3
Inappropriate	4.7	4.3	6.9	0.0				4.5
Percent Missing Data	5.2	31.1	23.4	9.5				22.9
Total 1992								
Appropriate	76.7	70.6	76.6	80.4				74.5
Equivocal	21.7	24.8	19.4	16.1				21.8
Inappropriate	1.6	4.7	4.0	3.6				3.8
Percent Missing Data	8.7	33.1	16.5	8.2				22.7
Total 1993								
Appropriate	72.5	73.6	76.5	76.5	65.2	49.5	40.8	71.0
Equivocal	26.0	23.0	20.5	20.5	33.8	37.6	57.1	25.6
Inappropriate	1.5	3.5	3.0	3.0	1.0	12.9	2.0	3.4
Percent Missing Data	19.7	16.8	7.7	7.7	19.8	41.3	66.4	21.0
Total								
Appropriate	74.3	72.8	79.9	79.9	65.2	49.5	40.8	72.7
Equivocal	23.4	23.2	17.6	17.6	33.8	37.6	57.1	23.6
Inappropriate	2.3	4.1	2.6	2.6	1.0	12.9	2.0	3.7
Percent Missing Data	12.6	26.2	8.2	8.2	19.8	41.3	66.4	21.9

Note: Percentages appropriate, equivocal, and inappropriate are calculated from the set of records for which appropriateness scores are available.
Percentage may not sum to 100 due to rounding.
The reported percentage missing is the proportion of all records within each category which were missing one or more of the component pieces of data needed to calculate an appropriateness score.

Source: Abstracts of clinical records among the seven demonstration hospitals, May 1991 through December 1993.
Appropriateness data are from a panel of experts.

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TABLE 8-4

PERCENT APPROPRIATE, EQUIVOCAL AND INAPPROPRIATE CABG OPERATION BY HOSPITAL BY CLINICAL PRESENTATION

	Hospital A	Hospital B	Hospital C	Hospital D	Hospital E	Hospital F	Hospital G	Total
Patient Is Not a Candidate for PTCA								
Chronic Stable Angina								
Appropriate	97.5	94.2	96.9	92.9	96.3	79.4	62.5	94.1
Equivocal	1.9	5.8	3.1	7.1	3.7	17.6	37.5	5.6
Inappropriate	0.6	0.0	0.0	0.0	0.0	2.9	0.0	0.4
Missing Approp. Data	15.1	43.5	21.0	9.7	15.6	41.4	57.1	25.6
Unstable Angina								
Appropriate	99.3	99.1	99.5	99.6	100.0	100.0	100.0	99.3
Equivocal	0.7	0.9	0.5	0.4	0.0	0.0	0.0	0.7
Inappropriate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Missing Approp. Data	6.9	15.6	6.4	8.6	12.2	23.5	90.5	12.9
AMI								
Appropriate	94.7	96.8	96.1	100.0	98.0	100.0	95.7	97.8
Equivocal	5.3	1.2	3.9	0.0	2.0	0.0	4.3	2.2
Inappropriate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Missing Approp. Data	12.8	16.7	4.9	0.0	7.3	20.0	62.9	15.7
Patient is a Candidate for PTCA								
Chronic Stable Angina								
Appropriate	75.8	86.5	78.9	71.4	77.8	54.4	16.7	74.4
Equivocal	21.7	7.7	17.2	28.6	22.2	26.5	79.2	20.8
Inappropriate	2.5	5.8	3.8	0.0	0.0	19.1	4.2	4.8
Missing Approp. Data	15.1	43.5	21.0	9.7	15.6	41.4	57.1	25.6
Unstable Angina								
Appropriate	76.1	76.9	80.9	83.7	69.6	46.2	100.0	77.7
Equivocal	21.4	17.8	15.2	13.0	27.8	53.8	0.0	18.1
Inappropriate	2.5	5.4	3.9	3.3	2.5	0.0	0.0	4.2
Missing Approp. Data	6.9	15.6	6.4	8.6	12.2	23.5	90.5	12.9
AMI								
Appropriate	64.0	62.7	59.7	61.5	58.4	35.0	60.9	61.0
Equivocal	34.7	36.0	35.1	38.5	41.6	65.0	39.1	37.3
Inappropriate	1.3	1.2	5.2	0.0	0.0	0.0	0.0	1.7
Missing Approp. Data	12.8	16.7	4.9	0.0	7.3	20.0	62.9	15.7

Source: Abstracts of clinical records among the seven demonstration hospitals, May 1991 through December 1993. Appropriateness data are from a panel of experts.

TABLE 8-5

PERCENT APPROPRIATE, EQUIVOCAL AND INAPPROPRIATE CABG OPERATION BY HOSPITAL BY EXTENT OF DISEASE

	Hospital							
	A	B	C	D	E	F	G	Total
Patient Is a Candidate for PTCA								
Left Main								
Appropriate	98.5	99.7	100.0	100.0	100.0	100.0	N/A	99.6
Equivocal	1.5	0.3	0.0	0.0	0.0	0.0	N/A	0.4
Inappropriate	0.0	0.0	0.0	0.0	0.0	0.0	N/A	0.0
Percent Missing Data	4.4	16.2	1.6	7.7	15.2	10.5	100.0	10.5
3-Vessel								
Appropriate	99.6	99.8	98.9	99.4	97.1	97.4	80.0	98.7
Equivocal	0.4	0.2	1.1	0.6	2.9	2.6	20.0	1.3
Inappropriate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Missing Data	1.5	13.6	1.6	7 0	12.5	2.6	56.7	11.0
2-Vessel with LAD								
Appropriate	98.8	100.0	100.0	98.6	100.0	100.0	100.0	99.7
Equivocal	1.2	0.0	0.0	1.4	0.0	0.0	0.0	0.3
Inappropriate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Missing Data	18.9	16.1	33.2	11.9	5.7	62.2	93.1	24.7
2-Vessel without LAD								
Appropriate	90.0	97.9	83.3	100.0	100.0	100.0	N/A	93.8
Equivocal	10.0	2.1	16.7	0.0	0.0	0.0	N/A	6.2
Inappropriate	0.0	0.0	0.0	0 0	0.0	0.0	N/A	0.0
Percent Missing Data	13.0	19.0	37.9	0.0	25.0	90.0	100.0	29.7
1-Vessel with LAD								
Appropriate	92.9	93.7	95.7	95 0	100.0	77.3	50.0	91.9
Equivocal	7.1	6.3	4.3	5.0	0.0	22.7	50.0	8.1
Inappropriate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Missing Data	17.6	21.3	4.2	9.1	0.0	0.0	0.0	12.2
1-Vessel without LAD								
Appropriate	50.0	84.0	60.7	100.0	100.0	11.1	N/A	69.9
Equivocal	37.5	16.0	39.3	0.0	0.0	66.7	N/A	27.2
Inappropriate	12.5	0.0	0.0	0.0	0.0	22.2	N/A	2.9
Percent Missing Data	0.0	12.3	3.4	0.0	33.3	0.0	100.0	11.2

TABLE 8-5 (continued)

PERCENT APPROPRIATE, EQUIVOCAL AND INAPPROPRIATE CABG OPERATION BY HOSPITAL BY ANATOMY OF DISEASE

	Hospital							
	A	B	C	D	E	F	G	Total
Patient Is Not a Candidate for PTCA								
Left Main								
Appropriate	98.5	99.7	100.0	100.0	100.0	100.0	N/A	99.6
Equivocal	1.5	0.3	0.0	0.0	0.0	0.0	N/A	0.4
Inappropriate	0.0	0.0	0.0	0.0	0.0	0.0	N/A	0.0
Percent Missing Data	4.4	16.2	1.6	7.7	15.2	10.5	100.0	10.5
3-Vessel								
Appropriate	81.4	88.2	89.7	93.1	70.5	86.8	44.4	85.4
Equivocal	18.6	11.8	10.3	6.9	29.5	13.2	55.6	14.6
Inappropriate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Missing Data	4.0	13.6	1.6	7.C	12.5	2.6	56.7	11.0
2-Vessel with LAD								
Appropriate	52.3	50.6	52.8	71.6	15.2	0.0	0.0	50.6
Equivocal	47.7	49.4	47.2	28.4	84.8	100.0	100.0	49.4
Inappropriate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Missing Data	18.9	16.1	33.2	11.9	5.7	62.2	93.1	24.7
2-Vessel without LAD								
Appropriate	0.0	0.0	0.0	0.0	0.0	0.0	N/A	0.0
Equivocal	85.0	91.5	83.3	100.0	83.3	100.0	N/A	88.7
Inappropriate	15.0	8.5	16.7	0.0	16.7	0.0	N/A	11.3
Percent Missing Data	13.0	19.0	37.9	0.0	25.0	90.0	100.0	29.7
1-Vessel with LAD								
Appropriate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Equivocal	92.9	92.1	95.7	90.0	100.0	81.8	50.0	91.3
Inappropriate	7.1	7.9	4.3	10.0	0.0	18.2	50.0	8.7
Percent Missing Data	17.6	21.3	4.2	9.1	0.0	0.0	0.0	12.2
1-Vessel without LAD								
Appropriate	0.0	0.0	0.0	0.0	0.0	0.0	N/A	0.0
Equivocal	0.0	14.0	3.6	0.0	50.0	0.0	N/A	8.7
Inappropriate	100.0	86.0	96.4	100.0	50.0	100.0	N/A	91.3
Percent Missing Data	0.0	12.3	3.4	0.0	33.3	0.0	100.0	11.2

Source: Abstracts of clinical records among the seven demonstration hospitals, May 1991 through December 1993.
Appropriateness data are from a panel of experts.

Effects of anatomy are much more dramatic if the patient is a candidate for PTCA. Over 99% of patients are appropriate candidates for surgery if LMD is present and 85.4% if three vessel disease is present. With less extensive disease, however, many fewer CABG operations are judged to be appropriate. In two vessel disease with LAD, 50.6% of cases are appropriate and 49.4% are equivocal. In two vessel disease without LAD, 88.7% of cases are equivocal and 11.3% are inappropriate. In one vessel disease with LAD, corresponding figures are 91.3% and 8.7%; and in one vessel disease without LAD, 91.3% of procedures are inappropriate.

8.5.3 Mean Appropriateness Scores

Mean appropriateness scores provide summative measure of the extent to which expected benefits exceed the risks of CABG surgery in a hospital's program. In a very real sense, the score can be considered a report card for clinical decision-making in the institution.

Table 8-6 presents mean scores overall and for individual hospitals from 1991-1993. For all years and all hospitals, scores were highly appropriate (mean 8.55) when patients were not candidates for PTCA and about a point lower (mean 7.23) when they were candidates for PTCA. Time trend was observed over the 1991-1993 period for the initial four sites. The three hospitals that entered the demonstration in 1993 had lower mean scores under all scenarios than the initial sites. In Hospitals E and F, mean scores reached the equivocal range (6.34 and 5.92, respectively) when patients were not candidates for PTCA.

Table 8-7 verifies the findings of the percent appropriate analysis presented in Section 8.5.2 with respect to the influence of the patient's clinical presentation on appropriateness scores. Mean scores are lowest for stable angina when the patient is not a candidate for PTCA. When the patient is a candidate for PTCA, mean scores are 1 to 1.5 points lower. The effect is most pronounced in the post-MI group in which the overall mean score borders on the equivocal range at 6.9. Hospitals F and G generally have lower scores than the other hospitals. This finding is especially pronounced in patients who present with chronic stable angina.

Table 8-8 presents mean scores according to the extent of coronary artery disease. Again, results mirror those of the percent appropriateness analysis. Scores are highest in patients with left main and three and two vessel disease and are lowest in patients with single vessel disease in the absence of LAD involvement. The effects of the extent of disease are especially pronounced if the patient is a candidate for PTCA. In this case, mean scores for patients with two vessel disease with or without LAD involvement or single vessel disease with LAD involvement fall in the equivocal range (6.7, 4.7, 5.0, respectively); those with single vessel disease and no LAD involvement are in the inappropriate range (mean 2.7).

TABLE 8-6

MEAN APPROPRIATENESS OF CABG SURGERY SCORES AND STANDARD ERRORS BY HOSPITAL BY PERIOD

	Hospital A		Hospital B		Hospital C		Hospital D		Hospital E		Hospital F		Hospital G		Total	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Patient Is Not a Candidate for PTCA																
1991																
May-Dec	8.5	0.1	8.7	0.0	8.5	0.1	8.9	0.1							8.6	0.0
1992																
Jan-June	8.6	0.1	8.7	0.0	8.5	0.1	8.9	0.1							8.6	0.0
July-Dec	8.6	0.1	8.6	0.1	8.5	0.1	8.7	0.1							8.6	0.0
Total 1992	**8.6**	**0.0**	**8.6**	**0.0**	**8.5**	**0.0**	**8.8**	**0.1**							**8.6**	**0.0**
1993																
Jan-June	8.5	0.1	8.6	0.0	8.4	0.1	8.6	0.1	8.5	0.1	8.0	0.3	8.0	0.3	8.5	0.0
July-Dec	8.6	0.1	8.7	0.0	8.5	0.0	8.7	0.1	8.5	0.1	7.9	0.2	7.6	0.2	8.5	0.0
Total 1993	**8.5**	**0.1**	**8.6**	**0.0**	**8.4**	**0.0**	**8.6**	**0.1**	**8.5**	**0.1**	**7.9**	**0.1**	**7.7**	**0.2**	**8.5**	**0.0**
Total All Years	**8.5**	**0.0**	**8.7**	**0.0**	**8.5**	**0.0**	**8.8**	**0.0**	**8.5**	**0.1**	**7.9**	**0.1**	**7.7**	**0.2**	**8.6**	**0.0**
Patient Is a Candidate for PTCA																
1991																
May-Dec	7.3	0.1	7.3	0.1	7.1	0.1	7.7	0.2							7.3	0.1
1992																
Jan-June	7.5	0.1	7.2	0.1	7.3	0.1	7.5	0.2							7.3	0.1
July-Dec	7.4	0.1	7.1	0.1	7.5	0.1	7.5	0.2							7.3	0.1
Total 1992	**7.5**	**0.1**	**7.2**	**0.1**	**7.4**	**0.1**	**7.5**	**0.1**							**7.3**	**0.1**
1993																
Jan-June	7.3	0.1	7.3	0.1	7.3	0.1	7.3	0.2	7.1	0.3	5.7	0.5	6.3	0.4	7.2	0.1
July-Dec	7.4	0.1	7.4	0.1	7.4	0.1	7.4	0.2	7.2	0.1	6.5	0.2	5.8	0.3	7.2	0.1
Total 1993	**7.3**	**0.1**	**7.3**	**0.1**	**7.4**	**0.1**	**7.3**	**0.1**	**7.2**	**0.1**	**6.4**	**0.2**	**5.9**	**0.2**	**7.2**	**0.0**
Total All Years	**7.4**	**0.1**	**7.3**	**0.0**	**7.3**	**0.1**	**7.5**	**0.1**	**7.2**	**0.1**	**6.4**	**0.2**	**5.9**	**0.2**	**7.3**	**0.0**

Source: Abstracts of clinical records among the seven demonstration hospitals, May 1991 through December 1993.
Appropriateness data are from a panel of experts.

TABLE 8-7

MEAN APPROPRIATENESS OF CABG SURGERY SCORES AND STANDARD ERRORS BY CLINICAL INDICATION BY HOSPITAL

	Hospital A	Hospital B	Hospital C	Hospital D	Hospital E	Hospital F	Hospital G	Total
Chronic Stable Angina								
Not PTCA Candidate								
Mean	8.3	8.1	8.3	8.2	8.3	7.5	7.2	8.2
Standard Error	0.1	0.1	0.0	0.1	0.1	0.2	0.2	*0.0*
PTCA Candidate								
Mean	7.4	7.4	7.4	7.2	7.4	6.2	5.7	*7.2*
Standard Error	0.1	0.2	0.1	0.3	0.2	0.3	0.3	*0.0*
Observations	185.0	92.0	529.0	31.0	32.0	116.0	56.0	*1041.0*
Missing Observations	28.0	40.0	111.0	3.0	5.0	48.0	32.0	*267.0*
Unstable Angina								
Not PTCA Candidate								
Mean	8.7	8.7	8.8	8.9	8.6	8.7	9.0	8.8
Standard Error	0.0	0.0	0.0	0.0	0.1	0.2	0.0	*0.0*
PTCA Candidate								
Mean	7.5	7.4	7.5	7.6	7.5	6.9	8.0	*7.5*
Standard Error	0.1	0.1	0.1	0.1	0.2	0.4	0.5	*0.0*
Observations	306.0	974.0	218.0	269.0	90.0	17.0	21.0	*1895.0*
Missing Observations	21.0	152.0	14.0	23.0	11.0	4.0	19.0	*244.0*
AMI								
Not PTCA Candidate								
Mean	8.5	8.6	8.5	8.5	8.4	8.7	8.1	8.5
Standard Error	0.1	0.0	0.1	0.1	0.1	0.1	0.2	*0.0*
PTCA Candidate								
Mean	7.0	6.9	6.9	6.8	6.9	6.6	6.0	6.9
Standard Error	0.2	0.1	0.1	0.3	0.2	0.2	0.3	*0.1*
Observations	86.0	490.0	162.0	39.0	109.0	25.0	62.0	*973.0*
Missing Observations	11.0	82.0	8.0	0.0	8.0	5.0	39.0	*153.0*

Source: Abstracts of clinical records among the seven demonstration hospitals, May 1991 through December 1993.
Appropriateness data are from a panel of experts

TABLE 8-8

MEAN APPROPRIATENESS OF CABG SURGERY SCORES AND STANDARD ERRORS BY EXTENT OF DISEASE AND HOSPITAL

	Hospital							
	A	B	C	D	E	F	G	Total
Left Main								
Not PTCA Candidate								
Mean	8.8	8.8	8.9	8.9	8.8	8.9	N/A	*8.9*
Standard Error	0.0	0.0	0.0	0.0	0.1	0.1	N/A	*0.0*
PTCA Candidate								
Mean	8.8	8.8	8.9	8.9	8.8	9.0	N/A	*8.9*
Standard Error	0.0	0.0	0.0	0.0	0.1	0.0	N/A	*0.0*
Observations	136	394	166	52	66	19	1	*854*
Missing Observations	6	64	3	4	10	2	1	*90*
3-Vessel								
Not PTCA Candidate								
Mean	8.5	8.7	8.4	8.8	8.4	8.2	7.8	*8.6*
Standard Error	0.0	0.0	0.0	0.0	0.1	0.1	0.1	*0.0*
PTCA Candidate								
Mean	7.4	7.5	7.4	8.0	6.8	7.2	6.1	*7.4*
Standard Error	0.1	0.0	0.0	0.1	0.1	0.1	0.2	*0.0*
Observations	274	626	384	172	120	39	104	*1719*
Missing Observations	11	85	6	12	15	1	59	*189*
2-Vessel with LAD								
Not PTCA Candidate								
Mean	8.5	8.6	8.5	8.6	8.3	8.6	7.0	*8.6*
Standard Error	0.1	0.0	0.1	0.1	0.1	0.2	0.0	*0.0*
PTCA Candidate								
Mean	6.6	6.6	7.0	6.6	6.4	6.6	4.0	*6.7*
Standard Error	0.1	0.1	0.1	0.1	0.2	0.2	0.0	*0.0*
Observations	106	299	184	84	35	37	29	*774*
Missing Observations	20	48	61	10	2	23	27	*191*
2-Vessel without LAD								
Not PTCA Candidate								
Mean	8.2	8.4	8.1	8.9	8.3	9.0	N/A	*8.3*
Standard Error	0.2	0.1	0.3	0.1	0.3	0.0	N/A	*0.1*
PTCA Candidate								
Mean	4.7	4.8	4.6	5.0	4.7	5.0	N/A	*4.7*
Standard Error	0.2	0.1	0.2	0.0	0.3	0.0	N/A	*0.1*
Observations	23	58	29	5	8	10	5	*138*
Missing Observations	3	11	11	0	2	9	5	*41*
1-Vessel with LAD								
Not PTCA Candidate								
Mean	8.3	8.5	8.0	8.5	8.2	7.3	6.0	*8.1*
Standard Error	0.2	0.1	0.1	0.2	0.3	0.2	1.5	*0.1*
PTCA Candidate								
Mean	5.2	4.9	5.4	5.0	5.2	4.8	3.5	*5.0*
Standard Error	0.3	0.1	0.1	0.2	0.1	0.3	1.0	*0.1*
Observations	17	80	48	22	5	22	2	*196*
Missing Observations	3	17	2	2	0	0	0	*24*
1-Vessel without LAD								
Not PTCA Candidate								
Mean	6.0	7.1	6.8	8.0	7.5	4.7	N/A	*6.8*
Standard Error	0.7	0.2	0.2	0.0	0.5	0.6	N/A	*0.1*
PTCA Candidate								
Mean	2.4	2.8	2.7	3.0	3.3	1.8	N/A	*2.7*
Standard Error	0.3	0.1	0.1	0.0	0.3	0.2	N/A	*0.1*
Observations	8	57	29	6	3	9	4	*116*
Missing Observations	0	7	1	0	1	0	4	*13*

Source: Abstracts of clinical records among the seven demonstration hospitals, May 1991 through December 1993.
Appropriateness data are from a panel of experts.

8.6 Multivariate Appropriateness Results

8.6.1 Rationale

A key focus of the appropriateness analysis is on the question of whether or not bundled payments induced providers to change clinical indications for performing CABG surgery. Multivariate regressions are used to examine the independent effects of hospital and time trends in appropriateness scores. Since no pre-demonstration data are available, there is no period of comparison. Our analysis of time trends during the demonstration requires the assumption that bundled payments would result in no immediate changes in clinical indications for surgery.

8.6.2 Regression Methods

Two multivariate approaches were used to assess the time trend in appropriateness of CABG surgery: ordinary least-squares (OLS) regression on the appropriateness score, and logistic regression on a dichotomous variable that is equal to one if the CABG surgery is deemed to be inappropriate or equivocal.

The (OLS) regression model is specified as follows:

$$App_i = f[Hosp_{ih}; Time_i] \qquad (1)$$

where App_i is the appropriateness score for the ith patient, $Hosp_{ih}$ is a vector of dummy variables representing 3 of the four original demonstration hospitals, and $Time_i$ is a time trend variable indicating the month during which the CABG surgery took place (equal to 1 if the surgery took place in the first month of the demonstration, 20 if it took place during the twentieth month, etc.). No patient risk factors are included in this model due to the fact that they were used in the construction of the appropriateness score. Least-squares estimation is an obvious choice for time trend analysis of the 1 to 9 appropriateness variable, given an assumption that the appropriateness score can be considered a continuous variable. But with so little variation in the pool of appropriateness scores, and with the interpretational problems inherent in judging small inter-hospital differences in mean appropriateness, it was felt that another approach should be employed as well, one that would specifically address the question of whether or not a CABG surgery was performed appropriately. A time trend coefficient in a regression on a dichotomous dependent variable such as "appropriate" versus "not appropriate" addresses more directly our interest in changes in the number of cases that are

inappropriate or equivocal, rather than simply addressing small variations in the scores among "appropriate" cases.

The logistic model is specified as:

$$P[NotApp_i] = g[Hosp_i; Time_i] \qquad (2)$$

where $P[NotApp_i]$ is the probability that the ith patient will have a rating of either equivocal or inappropriate (these cases will be referred to as "non-appropriate" cases). A discussion of logistic regression and the interpretation of logistic odds ratios is provided in Chapter 7 of this report. OLS and logistic regression is performed using appropriateness scores for both non-PTCA candidates and for PTCA candidates.

8.6.3 Least-Squares Regression Results on Appropriateness Score

Table 8-9 reports OLS regression results using data from the original four demonstration hospitals. The new sites were excluded because only a single year of data were available for them. A table reporting regressions using non-PTCA candidate data from all seven hospitals was created, however, and can be found in Appendix 8-B. Separate regressions were run for the pooled group of all patients; for each clinical presentation (except asymptomatic patients, for whom there were little appropriateness data available); and for different extent of disease categories. Hospital D, the site with the highest mean appropriateness score, is the referent site. The intercept term in each regression represents the estimated mean for Hospital D, evaluated during the first month of the demonstration. Each hospital's dummy coefficient represents the shift in mean appropriateness associated with that hospital relative to Hospital D. The time trend coefficient is an estimate of the change in the mean appropriateness scores during each succeeding month of the demonstration.

The assumption that patients are not PTCA candidates results not just in higher mean scores, but also in mean scores that vary to a lesser extent by clinical presentation and extent of disease. The intercept value for the pooled group of patients is 8.79 under the non-PTCA candidate assumption, and 7.43 under the PTCA candidate assumption. Mean scores under both assumptions tend to diminish with lesser extents of disease, though dramatically so for PTCA candidates. A non-PTCA candidate at Hospital D with 1-vessel disease without LAD involvement has a mean score of 7.95, while an otherwise-similar PTCA candidate has a score of 2.97.

The overall model shows that under the assumption that the demonstration patients are not candidates for PTCA, Hospitals A, B and C all have mean appropriateness scores that are

TABLE 8-9

ORDINARY LEAST-SQUARES REGRESSION RESULTS OF APPROPRIATENESS SCORE

	Overall (N=2889)	BY CLINICAL PRESENTATION: Chr. Stable Angina (N=654)	Unstable Angina (N=1554)	AMI (N=675)	EXTENT OF DISEASE: Left Main (N=689)	3-Vessel (N=1340)	2-Vessel with LAD (N=533)	2-Vessel without LAD (N=89)	1-Vessel with LAD (N=142)	1-Vessel without LAD (N=91)
Not PTCA Candidate										
INTERCEPT	8.79 ***	8.19 ***	8.93 ***	8.42 ***	8.96 ***	8.91 ***	8.73 ***	8.85 ***	8.49 ***	7.95 ***
HOSPITAL A	-0.22 ***	0.10	-0.18 ***	0.04	-0.12 *	-0.27 ***	-0.18 *	-0.69	-0.15	-1.99 ***
HOSPITAL B	-0.09 **	-0.08	-0.11 **	0.11	-0.08	-0.06	-0.01	-0.46	-0.01	-0.86
HOSPITAL C	-0.29 ***	0.07	-0.02	0.06	0.01	-0.38 ***	-0.12	-0.80 *	-0.51 **	-1.17 *
TREND	-0.002	0.000	-0.005 ***	0.001	-0.003 *	-0.006 ***	-0.005 *	0.002	-0.001	0.002
R-Square	0.020	0.004	0.015	0.002	0.019	0.073	0.015	0.060	0.075	0.095
Pr>F	0.000	0.463	0.001	0.787	0.011	0.000	0.128	0.184	0.015	0.037
PTCA Candidate										
INTERCEPT	7.43 ***	6.88 ***	7.64 ***	6.57 ***	8.97 ***	8.20 ***	6.71 ***	5.03 ***	5.00 ***	2.97 ***
HOSPITAL A	-0.09	0.30	-0.14	0.24	-0.15 **	-0.58 ***	0.02	-0.33	0.27	-0.61 **
HOSPITAL B	-0.19 *	0.33	-0.15	0.21	-0.08	-0.45 ***	0.02	-0.20	-0.07	-0.20
HOSPITAL C	-0.13	0.25	-0.10	0.25	-0.02	-0.56 ***	0.39 ***	-0.45	0.44 **	-0.31
TREND	0.002	0.014 **	-0.003	0.008	-0.003	-0.013 ***	-0.006	-0.001	-0.003	0.002
R-Square	.002	.007	.001	.003	.015	0.04	.037	.025	.088	.061
Pr>F	.238	.766	.633	.841	.025	0.00	.000	.540	.005	.155

NOTES:

***Indicates significance at the .01 level, ** at the .05 level, and * at .10.

The Pr>F statistic tests the joint significance of the Hospital dummy variables.

SOURCE: Abstracts of clinical records among seven demonstration hospitals, May, 1991 through December, 1993. Appropriateness data are from a panel of experts.

significantly lower than the referent. None of these differences, however, necessarily suggests that any of the sites have poor appropriateness scores. Compared to an intercept coefficient of 8.79, Hospitals A, B and C have coefficient estimates of -.22, -.09, and -.29, respectively. Even Hospital C, the site with the greatest negative coefficient, appears comfortably in the "appropriate" range (8.79 - .29 = 8.50). Under the assumption that these patients are candidates for PTCA, only Hospital B has a mean score significantly lower than that of the referent (-0.19, $p<.10$). The time trend for the pooled group is insignificant under both assumptions, indicating that no systematic change occurred in overall appropriateness scores.

No significant time trend or hospital differences are seen among chronic stable angina patients under the assumption that they are not PTCA candidates. There is, however, significant upward trend under the opposite assumption (0.014, $p<.05$), albeit one beginning from an intercept value below the minimum "appropriate" value of 7.

Unstable angina patients show a significant downward trend in appropriateness under the assumption that they are not PTCA candidates. It is important to note, however, that this small downward trend -.005 ($p<.01$) occurs only in this cohort of unstable patients for whom the mean appropriateness score is particularly high; the intercept term of 8.93, representing the mean score for Hospital D's unstable angina patients evaluated early in the demonstration, is substantially greater than the intercepts in the other presentation group regressions (8.19 and 8.42 for chronic stable angina and AMI, respectively). And the trend is of such a small magnitude (-.005) that even during the later months of the demonstration, the estimated mean score would still fall within the "appropriate" range. Evaluated in the last month of the demonstration, the estimate of Hospital D's mean score is 8.77 (8.93 - .005*32). No significant time trend is found under the PTCA candidate assumption.

Hospitals A and B show small but significant differences in appropriateness relative to Hospital D for unstable angina patients assumed not to be PTCA candidates. The hospital dummy variables are jointly significant at the 1 percent level of confidence, and all hospital coefficients have negative signs. The appropriateness score for Hospital A's unstable patient group is .18 points ($p<.01$) lower on average than that for Hospital D, and B's is .11 points ($p<.05$) lower. These very small differences, evaluated even in conjunction with the downward trend, are clinically insignificant, as all sites maintain a mean score greater than 8 (again assuming patients are not a candidate for PTCA). Hospital C's appropriateness score is not significantly different from Hospital D's. No significant hospital differences are present among chronic stable angina or AMI patients.

Regressions run by the extent of coronary artery disease anatomy on the non-PTCA candidate score show negative time trends that are significant for patients with left main (-.003, $p<.10$), 3-vessel (-.006, $p<.01$), and 2-vessel with left anterior descending (LAD) artery disease

(.005, p<.10). Under the PTCA candidate assumption, only 3-vessel disease shows a significant downward trend (-0.013, p<.01). 3-vessel disease shows significant and large hospital differences as well, under both assumptions. Mean scores for PTCA candidates at Hospitals A, B and C, evaluated at the end of the demonstration, approach the lower boundary of the appropriate range.

The only non-PTCA candidate patients to which the regression analysis suggests mean scores below the "appropriate" range (7-9) are 1-vessel disease without LAD involvement patients at Hospital A. Hospital A's coefficient is a robustly significant -1.99 (p<.01) despite the small sample (N=91). Starting with the intercept of 7.95, Hospital A's mean score, controlling for time, is 5.96. This is in the range deemed to be "equivocal." Under the PTCA candidate assumption, however, several classes of patients appear to have mean scores below the "appropriate" range. 1-vessel without LAD patients are actually estimated to be "inappropriate" CABG cases.

The principal finding of the OLS regression analysis is that there is no significant time trend in appropriateness among the pooled group of patients, regardless of the assumption made with regard to PTCA. Certain patient subgroups show a significant downward trends in appropriateness score, but these trends are not clinically important.

8.6.4 Logistic Regression Results on Inappropriate or Equivocal Surgery

Table 8-10 reports odds ratios and p-values for two logistic regression models predicting the likelihood of a patient being either equivocal or inappropriate. Actual regression coefficients are not reported, as they are not directly interpretable (see Chapter 7). The first model includes only an intercept term and hospital dummy variables, with Hospital C now the referent. The second model adds a monthly time trend. As in the OLS analysis, patient risk factors were omitted.

The time trend is insignificant under both PTCA assumptions. Patients undergoing surgery during later periods of the demonstration were no more likely to be non-appropriate cases than those undergoing surgery earlier. The inclusion of the trend variable has little effect on the hospital dummy coefficients. The only significant hospital differences in the likelihood of non-appropriate surgery are seen under the non-PTCA candidate assumption. Hence, patients at Hospital B are less than half as likely to receive non-appropriate CABG surgery than are patients at Hospital C (odds ratio .44, p=.02). The odds ratio for Hospital D is marginally significant (odds ratio .36, p slightly greater than .10). These odds ratios appear to validate in part the hospital-difference findings in the OLS analysis. While the referent hospitals are

TABLE 8-10

LOGISTIC RESULTS ON EQUIVOCAL AND INAPPROPRIATE CABG SURGERY

	Patient is Not a PTCA Candidate				Patient is a PTCA Candidate			
	Model 1		Model 2		Model 3		Model 4	
	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	0.03 ***	.00	0.03 ***	.00	0.32 ***	.00	0.33 ***	.00
HOSPITAL A	0.82	.59	0.79	.54	1.08	.58	1.07	.59
HOSPITAL B	0.45 **	.02	0.44 **	.02	1.16	.15	1.16	.15
HOSPITAL D	0.37	.11	0.36 *	.10	0.78	.13	0.79	.15
TREND	-	-	0.99	.44	-	-	1.00	.85
No. Observations	2,892		2,890		2,892		2,890	
Overall Chi-Square (p-value)	7.22	.07	7.79	.10	7.53	.06	7.29	.12

*** Indicates significance at the .01 level, ** at the .05 level, * at .10.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

SOURCE: Abstracts of clinical records among seven demonstration hospitals, May, 1991 through December, 1993. Appropriateness data are from a panel of experts.

different in the two analyses, Hospital D appears to stand out as having a particularly high level of appropriateness score, and a low probability of non-appropriate surgery.

8.6.5 Time Trend Regression Analysis Summary

While certain classes of patients appear to have a downward trend in their mean appropriateness scores, the trend is quite minor and is not present when evaluating the pooled group of all patients under either PTCA assumption. There is no significant trend in the proportion of CABG patients who are categorized as undergoing inappropriate or equivocal surgery. While the appropriateness scores under the PTCA candidate assumption are relatively low, and in some cases not "appropriate," this assumption is not likely to be a valid one. All the demonstration sites in the regression analysis are fully capable of angioplasty, and there is no reason to believe they would not use it for those cases in which it can be used. For this reason, the "not a candidate for PTCA" assumptions is the more reasonable one.

9.0 EVALUATION OF CLINICAL CORONARY ANGIOGRAPHY RESULTS BY QUANTITATIVE ANGIOGRAPHY

9.1 Introduction

9.1.1 Rationale

Coronary angiography results are one of the major determinants of the choice of treatment for coronary artery disease with CABG surgery, angioplasty, or medications. Accurate assessment of coronary artery anatomy and the extent of disease is critical to sound clinical decisions. At the same time, clinical interpretations of coronary angiograms involve considerable subjective judgment and have been amply demonstrated to exhibit marked inter- and intra-observer variations(ref). Hence, the potential exists both for errors in individual cases and for systematic biases that lead to inappropriate choices of treatment.

Quantitative angiography using computerized edge detection techniques has been demonstrated to yield highly reliable and reproducible results (ref). For this reason, the technique has been used in a number of studies to evaluate the progression or regression of coronary artery disease in response to dietary or invasive treatments (ref). Clinical applications have been limited, however, and insufficient evidence is currently available to document the superiority of quantitative angiography results in predicting responses to treatment.

The goals of this study are to:

1. quantify differences in estimates of the percent stenosis of lesions in the coronary arteries by clinical interpretations and quantitative angiography;

2. document any systematic differences among participating hospitals in the correlation between quantitative and visual estimates of the percent stenosis; and

3. evaluate clinical cardiac catheterization reports for the presence of clinically important information.

Previous studies have found that visual interpretations of coronary angiograms give systematically higher estimates of the degree of luminal diameter narrowing than quantitative angiography around the cutpoints for clinical decision-making (40 - 70 percent). Quantitative angiographic estimates, on the other hand, are higher in the 80 - 90 percent range (ref). Our study extends these findings by comparing clinical estimates both to quantitative estimates and

to visual estimates made by an investigator who is also skilled in quantitative angiography techniques.

The identification of systematic differences among hospitals in the relationships between clinical and quantitative angiographic estimates would suggest the need to reexamine practice patterns and consider the merits of adopting quantitative angiography techniques as the clinical standard.

9.1.2 Specific Objectives

1. Using quantitative angiography techniques, determine the percent diameter stenosis, minimal luminal diameter, and the "normal" reference segment diameter for the most severely obstructed lesion in each coronary artery or major branch.

2. Determine the flow grade and collateral circulation for each artery examined.

3. Examine the differences between quantitative angiographic estimates of percent stenoses, clinical estimates, and visual estimates made by the study investigator (MG).

4. Examine the relationships of differences between quantitative angiographic and clinical estimates for different degrees of stenosis.

5. Examine hospital and patient factors associated with differences between quantitative and clinical estimates of the degree of stenosis.

6. Compare the characteristics of vessels that were bypassed with those that were not bypassed.

7. Evaluate the relationships between the quality of angiograms and discrepancies between clinical (venual) and quantitative angiographic estimates.

8. Evaluate the completeness of important clinical information in the catheterization reports received from participating hospitals.

9.2 Study Design

9.2.1 Patient Samples

Twenty (20) coronary angiograms were randomly sampled from among patients who were enrolled in the demonstration during 1993 at six of the seven participating hospitals. St.

Lukes Hospital/Texas Heart Institute chose not to participate in the study. All patients must have received their coronary angiograms at the participating hospital but could have received it either on the same admission during which CABG surgery was performed (DRG 106) or during an earlier admission (DRG 107). Random sampling was performed from a list of eligible study participants supplied by HCFA.

Hospitals sent angiograms and copies of the clinical cardiac catheterization and surgeon's operative reports to Health Economics Research, Waltham, MA. These were logged and checked against the list of sampled patients. They were then forwarded to the Quantitative Angiography Core Laboratory at the Beth Israel Hospital, Boston, MA.

9.2.2 Quantitative Angiography Laboratory

Quantitative angiography interpretations were performed by C. Michael Gibson, M.D., Director of the Angiography Core Laboratory, and his colleagues using an automated edge detection algorithm(s). Dr. Gibson has served as the director of the TIMI 4 Angiographic Laboratory and the Angiographic Core Laboratory for the Harvard Atherosclerosis Reversibility Project (HARP) (1-14). The Beth Israel laboratory has been in operation since 1991 and has analyzed over 2,000 lesions from the U.S., and Canada.

The laboratory uses a DEC 5500 work station with software developed at the Brigham and Women's and Beth Israel Hospitals. A SONY SME 3500 projector, capable of 4-fold magnification of cineframes, was used for viewing and digitizing images.

9.3 Methods

9.3.1 Quantitative Angiography Procedures

9.3.1.1 Invoicing and Blinding Cinefilms

Cinefilms and cardiac catheterization and operative reports were invoiced as they were received by the laboratory. Cinefilms were blinded to the hospital of origin by removing the leader strip that contained identifying information and assigning a code number to both the film and leader strip. Catheterization and operative reports were also blinded.

9.3.1.2 Identifying Critical Lesions

Catheterization and surgical reports were reviewed by an angiographer to identify the location of the most critical lesion in each epicardial artery and to determine whether or not it was bypassed. A second quantitative angiographer used this information when analyzing the

cinefilm. This procedure was designed to assure that the same lesions were being analyzed by quantitative angiography as had been reported in catherization reports . All cinefilms were then over-read by the Director or Associate Director of the laboratory. Results were recorded on the Angiographic Core Laboratory Worksheet (see Appendix to Chapter 9).

Analysis was limited to the most severely narrowed lesion in each major epicardial artery or branch. If several lesions were present in a given artery or branch, the one with the smallest minimum lumen diameter was selected. The left main coronary artery was routinely analyzed.

The optimal single projection was selected that showed the stenotic segment in its greatest severity without foreshortening or overlapping branches. End-diastolic frames were given preference.

9.3.1.3 Quantitative Angiography Procedures and Definitions

Appendix 9 provides a detailed description of:

- Projections and items selection;
- Definitions of Segmental Coronary Anatomy;
- Flow Grade Assessment;
- Assessment of Collateral Circulation;
- Quantitation Angiography Analysis.

9.3.1.4 Assessment of the Quality of Angiography

Each cinefilm was carefully examined and graded according to the following criteria as being excellent, good, average, or poor.

1. Uninterpretable: The primary endpoint cannot be analyzed secondary to exceedingly poor film exposure or quality (i.e. no images on the film, inadequate injection of contrast material, etc.).

2. Poor: The primary endpoint can be analyzed but the film quality is poor secondary to under or overexposure, poor panning, poor engagement, poor contrast injection, excess collimation, partial obscuration by diaphragm. The distinction between TIMI grade one and two flow is

hard or impossible to make because the cinefilming is of inadequate duration to make the distinction. Injection begins before cinefilming.

3. Average: Adequate film quality. In some, but not all views, distal panning is adequate to assess TIMI flow grade. Dye is occasionally injected prior to the beginning of the cinefilming. Moderate overlap of vessels is present. Moderate obscuration of lesions by the diaphragm.

4. Good: Good film quality. During most injections there is adequate panning to assess flow to the distal vasculature and collaterals if present. Dye is not injected prior to the beginning of the cinefilming. Mild overlap of some vessels is present. Mild obscuration of lesions by the diaphragm.

5. Excellent: Excellent film quality. There is adequate panning to assess flow to the distal vasculature of the infarci-related artery and collaterals if present. Dye is not injected prior to the beginning of the cinefilming. The lesion is centered in the film during some portion of the cinerun to minimize pincushion distortion for quantitative analysis. The lesion is well layed out with no overlap of branches and orthogonal views are obtained to show the lesion in its tightest dimension.

9.3.2 Review of Cardiac Catheterization Reports

Cardiac catheterization reports were abstracted for information on the clinical indication for the angiogram, technical features of the procedure, and any complications. Variables assessed were:

- Clinical indication for coronary angiography
- Whether angiography was followed by failed angiography
- Whether an IABP had been inserted prior to angiography
- Whether vasodilators were used during the procedure
- Type and amount of contrast
- Number of catheters used
- Fluoroscopy time as a measure of radiation exposure
- Complications of the procedure

9.3.3 Clinical Data

Clinical data on sampled patients were obtained from the demonstration's core clinical database. Variables assessed were:

- Age, sex and race of the patient
- Clinical presentation at the time of hospitalization
- Revascularization priority
- History of previous CABG surgery
- Left ventricular ejection fraction
- Coronary artery anatomy
- Body surface area
- Number of conduits inserted during subsequent surgery
- Outcomes of CABG surgery: in-hospital mortality and whether a reoperation was required during the CABG surgery admission

9.4 Data Analysis

9.4.1 Specification of Variables

Primary outcomes are differences between the degrees of stenosis reported in catheterization reports versus those obtained by (1) quantitative angiography and (2) visual interpretations by the study investigator. The study investigator's own interpretations represent a "standard" for visual interpretations performed by a highly trained cardiologist not involved in the clinical process of care. A human benchmark, we believe, is an important strength of the design, as the majority of hospitals do not have access to quantitative angiography.

Variables are:

- Percent stenosis by the hospital's visual interpretation (HospVis%)
- Percent stenosis by quantitative angiography (Quant%)
- Percent stenosis by the investigator's visual interpretation (Invest%)

Each variable is explored both as a continuous and as a categorical variable.

Analyses then explore:

- the difference between the percent stenosis by the hospital's visual interpretation and the percent stenosis determined by quantitative angiography (HospVis% - Quant%)

- the difference between the percent stenosis by the hospital's visual interpretation and the percent stenosis by the quantitative angiographer's visual interpretation (HospVis%- Invest%)

- the relationship between each of these differences and the percent stenosis by quantitative angiography.

All other patient characteristics, clinical catheterization results, and quantitative angiography results are analyzed in form they were collected.

9.4.2 Descriptive Analyses

Descriptive results are presented for the total sample and by hospital for:

- the clinical characteristics of sampled patients
- information contained in the clinical catheterization reports
- quantitative angiography results

Significant differences among hospitals are analyzed by chi square analysis or t-tests as appropriate.

9.4.3 Regression Analyses

Multiple linear regressions examine patient and hospital factors associated with differences between the hospital's visual interpretation and quantitative angiographic and the investigator's visual interpretations.

Independent variables in these regressions include:

- hospital dummy variable

- patient's gender
- patient's age
- coronary artery system having the lesion
- clinical presentation of the patient at the time of the CABG surgery admission
- previous CABG surgery
- quantitative percent stenosis
- revascularization priority (emergent, urgent, or elective)

9.5 Descriptive Results

9.5.1 Clinical Characteristics of the Patient Sample

The clinical characteristics of patients in the quantitative angiography study are shown in Table 9-1. Patient samples are similar to the overall population enrolled in the Heart Bypass Demonstration during 1993 (Table 9-2) except that fewer sampled patients received elective CABG surgery (41.2 percent v. 56.8 percent); fewer had presented for their admissions with stable angina (23.5 percent v. 28.7 percent,) and more with AMI s (31.9 percent v. 24.1 percent,). In-hospital death rates were slightly higher in sample patients (5.0 percent v. 4.2 percent). A possible reason for observed differences are that patients who received their angiograms at outside hospitals were excluded from the sampling frame.

9.5.2 Catheterization Report Data

Results are presented in Table 9-3. Information on the clinical diagnosis or the indication for angiography was missing from 24 percent of reports overall and from 45 percent and 50 percent of reports, respectively, in Hospitals (IV and V). Where present, the clinical indication was stated to be stable angina in 35 percent of patients, unstable angina in 34 percent, and post-myocardial infarction in 26 percent. This proportion of patients with stable angina is higher than that reported in Table 9-1 (34 percent v. 23.5 percent). This difference may be accounted for by patients who were admitted with unstable angina which stabilized before coronary angiography.

Three patients underwent angiography with an IABP in place, and 8 patients received an angioplasty which failed and necessitated urgent CABG surgery.

One or more complications of catheterization were reported in 10 percent of patients and included cardiac arrest in 1.7 percent of patients, AMI in 1.7 percent, increased angina in 3.4 percent, and a hematoma in 2.5 percent. Those figures are almost certainly underestimates

TABLE 9-1

CLINICAL CHARACTERISTICS OF SAMPLED PATIENTS

	TOTAL (N=119)	I (N=20)	II (N=19)	III (N=20)	IV (N=20)	V (N=20)	VI (N=20)
CHARACTERISTIC							
Age							
Mean	69.9	69.8	68.4	72.0	70.8	67.8	70.8
SE	0.9	1.4	3.9	1.7	1.0	2.2	1.1
Sex							
% Male	63.0	60.0	42.1	60.0	65.0	70.0	80.0
% Female	34.5	40.0	57.9	35.0	25.0	30.0	20.0
% Missing	2.5	0.0	0.0	5.0	10.0	0.0	0.0
Race							
% White	83.2	100.0	42.1	95.0	80.0	100.0	80.0
% Black	2.5	0.0	5.3	0.0	5.0	0.0	5.0
% Other	2.5	0.0	0.0	0.0	0.0	0.0	15.0
% Missing	11.8	0.0	52.6	5.0	15.0	0.0	0.0
Previous CABG							
% Yes	10.9	10.0	0.0	10.0	30.0	10.0	5.0
% No	88.2	85.0	100.0	90.0	70.0	90.0	95.0
% Missing	0.8	5.0	0.0	0.0	0.0	0.0	0.0
Revascularization priority							
% Elective	41.2	80.0	52.6	0.0	35.0	0.0	80.0
% Urgent	34.5	0.0	47.4	65.0	15.0	80.0	0.0
% Emergent	15.1	20.0	0.0	30.0	10.0	20.0	10.0
% Missing	9.2	0.0	0.0	5.0	40.0	0.0	5.0
Clinical Presentation							
% Asymptomatic	0.8	0.0	0.0	0.0	5.0	0.0	0.0
% Stable angina	23.5	5.0	15.8	10.0	35.0	10.0	65.0
% Unstable angina	40.3	75.0	52.6	40.0	20.0	55.0	0.0
% AMI	31.9	20.0	26.3	45.0	30.0	35.0	35.0
% Missing	3.4	0.0	5.3	5.0	10.0	0.0	0.0
Left Main Coronary Artery Disease (> = 50% Stenosis)							
% Yes	20.2	25.0	26.3	25.0	0.0	25.0	20.0
% No	74.8	70.0	63.2	70.0	90.0	75.0	80.0
% Missing	5.0	5.0	10.5	5.0	10.0	0.0	0.0
Number of Vessels with >70% Stenosis, including LMCA							
% 0 vessels	1.8	0.0	0.0	0.0	5.6	0.0	5.0
% 1 vessels	15.0	15.8	17.7	15.8	5.6	0.0	35.0
% 2 vessels	33.6	21.1	35.3	26.3	33.3	50.0	35.0
% 3 vessels	46.0	63.2	41.2	57.9	55.6	35.0	25.0
% 4 vessels	3.5	0.0	5.9	0.0	0.0	15.0	0.0
Left Ventricular Ejection Fraction							
% <1 to 25	5.9	5.0	10.5	5.0	0.0	0.0	15.0
% 25 to 50	30.3	35.0	31.6	55.0	5.0	30.0	25.0
% 50 +	47.9	60.0	57.9	30.0	10.0	70.0	60.0
% Missing	16.0	0.0	0.0	10.0	85.0	0.0	0.0
Body Surface Area Ratio							
Mean	1.9	1.9	1.8	1.9	1.9	1.9	2.0
SE	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Number of Conduits in CABG Surgery							
% 0	3.4	0.0	15.8	0.0	0.0	0.0	5.0
% 1 to 2	25.2	25.0	10.5	20.0	25.0	35.0	35.0
% 3	44.5	30.0	57.9	50.0	45.0	55.0	30.0
% 4	21.0	30.0	15.8	20.0	20.0	10.0	30.0
% 5+	3.4	15.0	0.0	5.0	0.0	0.0	0.0
% Missing	2.5	0.0	0.0	5.0	10.0	0.0	0.0
Outcome of CABG surgery							
Reoperation							
% Yes	4.2	5.0	10.5	0.0	5.0	5.0	0.0
% No	55.5	90.0	15.8	95.0	0.0	30.0	100.0
% Missing	40.3	5.0	73.7	5.0	95.0	65.0	0.0
In-hospital death							
% Yes	5.0	10.0	0.0	10.0	0.0	5.0	5.0
% No	92.4	90.0	100.0	85.0	90.0	95.0	95.0
% Missing	2.5	0.0	0.0	5.0	10.0	0.0	0.0

Note: Characteristics based on clinical registry data, not cath lab report.

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

TABLE 9-2

CLINICAL CHARACTERISTICS OF THE SAMPLING UNIVERSE: ALL PATIENTS ENROLLED IN THE DEMONSTRATION DURING 1993 WHO RECEIVED THEIR CORONARY ANGIOGRAMS IN THE HOSPITAL PERFORMING CABG SURGERY (CLINICAL STUDY DATAFILE - 1993 PATIENTS)

	TOTAL (N=2075)	I (N=691)	II (N=254)	III (N=411)	IV (N=146)	V (N=143)	VI (N=172)
CHARACTERISTIC							
Age							
Mean	71.1	70.6	70.8	71.7	71.8	70.6	71.6
SE	0.2	0.2	0.6	0.3	0.4	0.6	0.5
Sex							
% Male	66.8	66.3	62.6	68.4	73.3	61.5	70.4
% Female	33.2	33.7	37.4	31.6	26.7	38.5	29.7
Race							
% White	88.9	96.7	52.8	97.3	92.5	96.5	81.4
% Black	2.6	2.8	1.6	1.7	6.2	3.5	1.7
% Hispanic	0.2	0.1	0.0	0.2	0.0	0.0	1.2
% Asian	0.2	0.0	0.0	0.5	0.0	0.0	0.6
% Native American	0.1	0.0	0.0	0.0	0.0	0.0	0.6
% Other	0.2	0.4	0.0	0.2	0.0	0.0	0.0
% Missing	7.9	0.0	45.7	0.0	1.4	0.0	14.5
Previous CABG							
% Yes	17.4	11.6	10.2	11.2	13.0	8.4	14.5
% No	82.3	88.4	89.8	88.8	87.0	91.6	82.6
% Missing	0.3	0.0	0.0	0.0	0.0	0.0	2.9
Revascularization priority							
% Elective	56.8	80.3	48.0	26.0	45.9	25.2	84.3
% Urgent	28.4	3.2	40.9	63.0	20.6	64.3	5.2
% Emergent	12.2	16.1	7.9	11.0	11.6	9.8	8.7
% Missing	2.6	0.4	3.2	0.0	21.9	0.7	1.7
Clinical Presentation							
% Asymptomatic	3.1	5.9	0.4	0.0	4.1	0.7	4.1
% Stable angina	28.7	3.0	25.2	58.4	38.4	17.5	67.4
% Unstable angina	42.7	62.7	40.6	28.0	14.4	60.8	9.9
% AMI	24.1	28.1	28.4	13.6	42.5	20.3	14.5
% Missing	1.4	0.3	5.5	0.0	0.7	0.0	0.6
Left Main Coronary Artery Disease (> = 50% Stenosis)							
% Yes	20.8	25.8	24.0	21.4	0.7	21.7	11.1
% No	73.2	65.1	66.9	77.6	99.3	78.3	77.9
% Missing	6.0	9.1	9.1	1.0	0.0	0.0	11.1
Number of Vessels with >70% Stenosis, including LMCA							
% 0 vessels	1.5	0.3	1.3	0.7	0.7	0.0	11.1
% 1 vessels	13.5	12.3	13.9	13.8	8.2	9.8	25.5
% 2 vessels	35.5	34.7	32.9	39.3	37.0	28.7	37.3
% 3 vessels	43.6	45.9	45.0	41.3	54.1	49.7	22.9
% 4 vessels	5.9	6.9	6.9	4.9	0.0	11.9	3.3
Left Ventricular Ejection Fraction							
% < to 25	7.4	4.5	5.9	10.2	4.1	0.0	23.3
% 25 to 50	37.5	35.5	31.1	61.3	21.2	31.5	17.4
% 50 +	48.0	58.8	55.5	28.2	13.0	61.5	59.3
% Missing	7.1	1.3	7.5	0.2	61.6	7.0	0.0
Number of Conduits in CABG Surgery							
% 0	2.0	0.7	10.6	0.2	1.4	0.0	1.2
% 1 to 2	25.0	19.4	24.0	23.4	26.0	39.9	39.5
% 3	40.1	36.8	40.6	44.3	38.4	46.9	38.4
% 4	26.5	32.4	22.1	27.3	28.1	12.6	18.0
% 5+	6.4	10.7	2.8	4.9	6.2	0.7	2.9
Outcome of CABG surgery							
Reoperation							
% Yes	4.2	2.8	6.7	4.9	3.4	9.1	1.2
% No	71.3	96.4	12.6	94.9	0.0	26.6	98.8
% Missing	24.5	0.9	80.7	0.2	96.6	64.3	0.0
In-hospital death							
% Yes	4.2	5.4	3.2	5.1	0.7	4.2	2.3
% No	95.6	94.7	96.1	94.9	99.3	95.1	97.7
% Missing	0.2	0.0	0.8	0.0	0.0	0.7	0.0

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

heart\tables\TAB9-2.XLS\vd

TABLE 9-3

INFORMATION FROM CARDIAC CATHERIZATION REPORTS

	TOTAL (N=119)	I (N=20)	II (N=19)	III (N=20)	IV (N=20)	V (N=20)	VI (N=20)
CHARACTERISTIC							
Clinical indication for angiography							
% Stable Angina	26.9	60.0	15.8	10.0	10.0	35.0	30.0
% Unstable Angina	26.1	25.0	21.1	20.0	30.0	30.0	30.0
% AMI w/angina	12.6	5.0	42.1	15.0	0.0	5.0	10.0
% AMI w/o angina or UK	7.6	5.0	10.5	0.0	10.0	10.0	10.0
% Other	3.4	0.0	5.3	5.0	5.0	5.0	0.0
% Missing	23.5	5.0	5.3	50.0	45.0	15.0	20.0
Failed PTCA							
% Yes	6.7	5.0	5.3	10.0	5.0	0.0	15.0
% No	91.6	90.0	94.7	85.0	95.0	100.0	85.0
% Missing	1.7	5.0	0.0	5.0	0.0	0.0	0.0
IABP inserted before angiography							
% Yes	2.5	10.0	0.0	0.0	0.0	5.0	0.0
% No	95.8	85.0	100.0	95.0	100.0	95.0	100.0
% Missing	1.7	5.0	0.0	5.0	0.0	0.0	0.0
Vasodilator used during angiography							
% Yes	11.8	40.0	0.0	10.0	0.0	0.0	20.0
% No	88.2	60.0	100.0	90.0	100.0	100.0	80.0
Type of contrast agent							
% Ionic	19.3	55.0	0.0	0.0	20.0	0.0	40.0
% Non-ionic	16.8	35.0	0.0	10.0	45.0	0.0	10.0
% Missing	63.9	10.0	100.0	90.0	35.0	100.0	50.0
Amount of contrast agent							
% Missing	84.9	95.0	100.0	50.0	80.0	100.0	85.0
Number of angiographic catheters used							
% 0-2	11.8	30.0	21.1	5.0	10.0	0.0	5.0
% 3	29.4	30.0	5.3	5.0	55.0	0.0	80.0
% 4	6.7	10.0	5.3	5.0	20.0	0.0	0.0
% 5+	4.2	5.0	0.0	0.0	10.0	0.0	10.0
% Missing	47.9	25.0	68.4	85.0	5.0	100.0	5.0
Flouroscopy time							
% Missing	94.1	100.0	100.0	95.0	80.0	100.0	90.0
Complications							
% None recorded	90.8	80.0	89.5	95.0	95.0	90.0	95.0
% Death	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% AMI	1.7	0.0	5.3	5.0	0.0	0.0	0.0
% Bleeding with transfusion	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Allergic reaction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Cardiac arrest in cath lab	1.7	10.0	0.0	0.0	0.0	0.0	0.0
% Increased angina after cath	3.4	5.0	0.0	0.0	5.0	5.0	5.0
% Hematoma	2.5	5.0	5.3	0.0	0.0	5.0	0.0

Note: Characteristics provided by cath lab report.

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

heart\tables\TAB9-3.XLS\nd

in view of the tendency to under-report complications that occur during catheterization procedures. The fact that complications such as 1 vessel angina, hematoma, or wound (puncture sites) are frequently observed after the patient leaves the catheterization laboratory is another reason for underreporting complications.

The angiographic procedure was described in varying detail in catheterization reports. Data were missing from a large number of reports, however, on certain aspects of the procedure. The type of contrast agent was missing in 63.9 percent of cases. When present, 53.5 percent reported use of (more expensive, but less allergenic) non-ionic agents, and 46.5 percent reported use of a ionic agent. The amount of contrast agent used was missing from 85 percent of reports; and the amounts reported generally referred only to bolus injections used for left ventricular angiography. Data on the types and numbers of catheters used were missing in 48 percent of cases; when present the modal number of catheters was 3. Total fluoroscopy time was recorded in only 6 percent of cases, even though radiation exposure is an important risk factor. Use of a vasodilator was reported in 11.8 percent of cases; this figure almost certainly reflects underreporting.

9.5.3 Quantitative Angiography Results

Table 9-4 describes qualitative findings. Angiographic quality was judged to be excellent in 7.6 percent of cineangiograms, good in 21 percent, and poor in 21 percent. Hospitals (IV and VI) had poor quality angiograms in 35 percent of cases. Hospital (I) had the best overall quality of angiograms (good in 40 percent, average in 55 percent and poor in 5 percent). Catheter size was 7F in 54.6 percent of cases and 6F in 35.3 percent. The right coronary circulation was dominant in 89 percent of patients.

Quantitative angiographic results are summarized in Table 9-5. Data on percent stenosis was available on all lesions in the LMCA but only to the tightest lesion in each epicardial coronary artery or branch system. Only lesions with 10 percent or greater stenosis by hospital visual estimates are reported in Table 9-5.

Analysis of 33 LMCA lesions revealed a mean stenosis of 41.1 percent and LMCA stenoses of 50 percent or greater in 42.5 percent of patients. LMCA lesions were isolated in 1.7 percent of patients and were in an ostial location in 8.5 percent of patients. Nearly all (96.6 percent) LMCA lesions were bypassed during CABG surgery.

A total of 317 lesions were examined in the left, circumflex and right coronary artery systems (LCRA). Of these, 20.5 percent represented total occlusions; 32.8 percent were of 70-99 percent stenosis; and 31.5 percent were 50-69 percent stenosis. A higher proportion of left

TABLE 9-4

QUALITATIVE FINDINGS FROM EXAMINATION OF SAMPLED CORONARY CINEANGIOGRAMS

Characteristic	TOTAL (N=119)	I (N=20)	II (N=19)	III (N=20)	IV (N=20)	V (N=20)	VI (N=20)
Angiographic Quality							
% Excellent	7.6	0.0	10.5	0.0	20.0	0.0	15.0
% Good	21.0	40.0	15.8	25.0	15.0	10.0	20.0
% Average	50.0	55.0	57.9	65.0	30.0	65.0	30.0
% Poor	21.0	5.0	15.8	10.0	35.0	25.0	35.0
Catheter Size							
% 5F	2.5	10.0	0.0	0.0	0.0	0.0	5.0
% 6F	35.3	40.0	0.0	5.0	35.0	80.0	50.0
% 7F	54.6	30.0	94.7	95.0	60.0	20.0	30.0
% 8F	7.6	20.0	5.3	0.0	5.0	0.0	15.0
Dominance of coronary circulation							
% Right	89.1	90.0	89.5	90.0	85.0	95.0	85.0
% Left	5.9	5.0	0.0	10.0	0.0	5.0	15.0
% Codominant	2.5	5.0	5.3	0.0	5.0	0.0	0.0
% Missing	2.5	0.0	5.3	0.0	10.0	0.0	0.0

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

TABLE 9-5

QUANTITATIVE ANGIOGRAPHY RESULTS

CHARACTERISTIC	LEFT MAIN CORONARY ARTERY	EPICARDIAL CORONARY ARTERIES			
		Left	Circumflex	Right	Total
Quantitative Angiography					
Number of lesions	33	120	98	99	317
Missing	2	1	1	1	3
Mean Percent	41.1 %	71.8 %	68.8 %	75.9 %	72.1 %
Std. Error	1.9	1.6	2.0	2.3	1.1
< 40	48.5	2.5	7.1	6.1	5.1
40 to 49	9.1	8.3	12.2	10.1	10.1
50 to 59	15.2	14.2	12.2	10.1	12.3
60 to 69	21.2	24.2	19.4	13.1	19.2
70 to 79	6.1	21.7	19.4	13.1	18.3
80 to 99	0.0	13.3	18.4	12.1	14.5
total occlusion	0.0	15.8	11.2	35.4	20.5
Total	100.1 %	100.0 %	100.0 %	100.0 %	100.0 %
Reference Diameter (mm)					
Mean	4.6	3.2	3.2	3.5	3.3
SE	0.1	0.2	0.1	0.2	0.2
Minimum luminal diameter (mm)					
Mean	3.5	1.1	1.2	1.2	1.2
SE	0.1	0.1	0.1	0.1	0.1
Average diameter (mm)					
Mean	4.2	2.3	3.2	2.6	2.7
SE	0.1	0.1	0.8	0.1	0.3
Critical lesion bypassed					
% Yes	96.6	94.6	80.5	81.4	86.3
% No	3.4	5.4	19.5	18.6	13.7
Isolated Left Main					
% Yes	1.7				
% No	98.3				
Ostial Lesion					
% Yes	8.5				
% No	91.5				

*Study sample includes only those lesions with a visual % stenosis (by the hospital) greater than 10%.

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

heart\tables\TAB9-5.XLS\ind

coronary artery lesions were bypassed than in the circumflex or right systems (94.6 percent v. 80.5 percent and 81.4 percent, respectively).

9.5.4 Differences Between Quantitative Angiographic and Visual Interpretations of the Percent Stenosis

Quantitative angiographic estimates are compared to the hospitals' visual and the investigator's visual estimates in Table 9-6. In all coronary arteries, the mean percent stenosis is highest by the hospitals' visual interpretations, and lower by quantitative angiography. The investigator's visual interpretations are intermediate but are much closer to quantitative angiography.

In the left main coronary artery, stenosis of 50 percent or more was found by quantitative angiography in 42.5 percent of lesions, in 54.6 percent by investigator visual estimates, and in 62.8 percent by hospital visual estimates. In the epicardial arteries, the proportions of lesions with 70-99 percent stenosis are 57.2 percent, 50.9 percent, and 32.8 percent, respectively, by the three techniques. Corresponding values for 40-69 percent lesions are 19.4 percent, 22.7 percent, and 41.6 percent. Hence, hospital visual estimates are substantially higher around the threshold for clinical decision-making (> or = 70 percent) and are correspondingly lower below this level. This finding is especially striking in the left coronary artery system where visual inspection "sees" much more occlusion in the 80-99 percent range.

Differences in percent stenoses between quantitative angiographic and the hospitals' visual interpretations (HospVis% - Quant%), overall and by hospital, are presented in Table 9-7. Results are based on 317 lesions in the epicardial arteries and 33 lesions in the LMCA . The overall mean differences between the hospitals' visual estimate and the quantitative estimates was 9.2 percent in epicardial arteries and 11.9 percent in the LMCA. In epicardial arteries, the distribution of differences included 45.8 percent of lesions within + or - 10 percent by the two techniques and 26.1 percent that were 20 percent or more higher by hospital visual estimates. In the LMCA, corresponding figures were 33.3 percent and 42.4 percent.

Patterns varied considerably among hospitals. Mean differences in the epicardial arteries were highest in Hospitals (I, IV, and V) (16.8 percent, 14.6 percent, and 12.6 percent, respectively) and lowest in hospital (II) (-3.4 percent). The small numbers of lesions analyzed in the LMCA prevent meaningful comparisons among hospitals.

Differences between the hospitals' visual interpretations and those by the investigator (HospVis% - InvestVis%) are presented in Table 9-8. In the epicardial arteries, the hospitals' visual estimates are higher, but the mean difference is less than for (HospVis% - Quant%) (4.6

TABLE 9-6

COMPARISON OF PERCENT STENOSIS BY QUANTITATIVE ANGIOGRAPHIC, HOSPITAL VISUAL AND INVESTIGATOR VISUAL INTERPRETATIONS

CHARACTERISTIC	LEFT MAIN CORONARY ARTERY	EPICARDIAL CORONARY ARTERIES			
		Left	Circumflex	Right	Total
Quantitative Angiography					
Number of lesions	33	120	98	99	317
Missing	2	1	1	1	3
Mean Percent	41.1 %	71.8 %	68.8 %	75.9 %	72.1 %
Std. Error	1.9	1.6	2.0	2.3	1.1
< 40	48.5	2.5	7.1	6.1	5.1
40 to 49	9.1	8.3	12.2	10.1	10.1
50 to 59	15.2	14.2	12.2	10.1	12.3
60 to 69	21.2	24.2	19.4	13.1	19.2
70 to 79	6.1	21.7	19.4	13.1	18.3
80 to 99	0.0	13.3	18.4	12.1	14.5
total occlusion	0.0	15.8	11.2	35.4	20.5
Total	100.1 %	100.0 %	100.0 %	100.0 %	100.0 %
Hospital's Visual Interpretation					
Number of lesions	35	121	99	100	320
Missing	0	0	0	0	0
Mean Percent	55.0 %	81.9 %	77.8 %	83.2 %	81.0 %
Std. Error	4.3	1.7	1.8	2.1	1.1
< 40	31.4	3.3	2.0	4.0	3.1
40 to 49	5.7	3.3	1.0	2.0	2.2
50 to 59	14.3	5.0	10.1	7.0	7.2
60 to 69	11.4	7.4	13.1	10.0	10.0
70 to 79	17.1	12.4	15.2	9.0	12.2
80 to 99	20.0	52.9	47.5	33.0	45.0
total occlusion	0.0	15.7	11.1	35.0	20.3
Total	99.9 %	100.0 %	100.0 %	100.0 %	100.0 %
Investigator's Visual Interpretation					
Number of lesions	35	120	99	99	318
Missing	2	1	0	1	2
Mean Percent	40.8 %	77.9 %	72.7 %	78.8 %	76.6 %
Std. Error	2.5	1.7	2.4	2.4	1.3
< 40	45.4	1.7	10.1	7.1	6.0
40 to 49	0.0	2.5	2.0	4.0	2.8
50 to 59	21.2	13.3	13.1	10.1	12.3
60 to 69	9.1	7.5	10.1	5.1	7.6
70 to 79	9.1	10.0	11.1	7.1	9.4
80 to 99	15.2	49.2	42.4	31.3	41.5
total occlusion	0.0	15.8	11.1	35.4	20.4
Total	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

*Study sample includes only those lesions with a visual % stenosis (by the hospital) greater than 10%.

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

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TABLE 9-7

DIFFERENCES IN PERCENT STENOSIS BETWEEN THE HOSPITAL'S VISUAL AND QUANTITATIVE ESTIMATES, BY HOSPITAL
(HOSP. VIS % - QUANT. %)

	TOTAL	I	II	III	IV	V	VI
EPICARDIAL ARTERIES							
Number of lesions	317	53	55	49	53	57	50
Missing	3	0	1	1	0	0	1
Mean difference	**9.2 %**	**16.8 %**	**-3.4 %**	**5.2 %**	**14.6 %**	**12.6 %**	**9.2 %**
Std. Error	0.9	2.2	2.5	2.2	1.7	1.9	2.2
<(-20)	4.1	0.0	12.7	8.2	0.0	1.8	2.0
(-20) to (-11)	6.0	1.9	16.4	6.1	0.0	1.8	10.0
(-10) to (-1)	7.3	9.4	12.7	8.2	1.9	3.5	8.0
0 to 9	38.5	24.5	43.6	44.9	45.3	38.6	34.0
10 to 19	18.0	24.5	9.1	20.4	17.0	21.1	16.0
20 to 29	16.7	22.6	3.6	4.1	22.6	21.1	26.0
30 to 39	6.6	7.6	0.0	6.1	11.3	12.3	2.0
>=40	2.8	9.4	1.8	2.0	1.9	0.0	2.0
Total	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %
LEFT MAIN CORONARY ARTERY							
Number of lesions	33	6	7	6	2	8	4
Missing	2	0	0	0	1	1	0
Mean difference	**11.9 %**	**6.7 %**	**2.9 %**	**8.3 %**	**55.0 %**	**-0.1 %**	**43.3 %**
Std. Error	4.6	10.3	4.7	6.7	10.0	5.9	19.7
<(-20)	3.0	16.7	0.0	0.0	0.0	0.0	0.0
(-20) to (-11)	12.1	16.7	0.0	16.7	0.0	25.0	0.0
(-10) to (-1)	21.2	0.0	28.6	16.7	0.0	50.0	0.0
0 to 9	12.1	0.0	42.9	0.0	0.0	12.5	0.0
10 to 19	9.1	16.7	0.0	16.7	0.0	0.0	25.0
20 to 29	24.2	33.3	28.6	50.0	0.0	0.0	25.0
30 to 39	6.1	16.7	0.0	0.0	0.0	12.5	0.0
>=40	12.1	0.0	0.0	0.0	100.0	0.0	50.0
Total	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

* Study sample includes only those lesions with a visual % stenosis (by the hospital) greater than 10%.

Source Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

TABLE 9-8

DIFFERENCES IN PERCENT STENOSIS BETWEEN HOSPITAL'S VISUAL AND INVESTIGATOR VISUAL ESTIMATES, BY HOSPITAL
(HOSP. VIS.% - INVEST. VIS. %)

	TOTAL	I	II	III	IV	V	VI
EPICARDIAL ARTERIES							
Number of lesions	318	53	55	49	53	57	51
Missing	2	0	1	1	0	0	0
Mean difference	**4.6 %**	**9.0 %**	**-8.0 %**	**2.2 %**	**9.3 %**	**7.4 %**	**7.7 %**
Std. Error	0.9	2.2	2.3	2.9	1.9	1.7	2.0
<(-20)	5.0	1.9	14.6	12.2	0.0	0.0	2.0
(-20) to (-11)	3.8	5.7	10.9	2.0	0.0	3.5	0.0
(-10) to (-1)	13.8	7.6	21.8	18.4	5.7	12.3	17.7
0 to 9	43.1	41.5	41.8	34.7	52.8	50.9	35.3
10 to 19	15.4	20.8	7.3	14.3	13.2	14.0	23.5
20 to 29	11.0	9.4	3.6	8.2	20.8	12.3	11.8
30 to 39	3.5	5.7	0.0	2.0	1.9	5.3	5.9
>=40	4.4	7.6	0.0	8.2	5.7	1.8	3.9
Total	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %
LEFT MAIN CORONARY ARTERY							
Number of lesions	33	6	7	6	2	8	4
Missing	2	0	0	0	1	1	0
Mean difference	11.6 %	1.0 %	5.5 %	13.9 %	49.1 %	6.0 %	26.9 %
Std. Error	4.0	12.3	3.3	4.1	5.2	5.4	19.1
<(-20)	9.1	33.3	0.0	0.0	0.0	12.5	0.0
(-20) to (-11)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(-10) to (-1)	12.1	0.0	28.6	0.0	0.0	12.5	25.0
0 to 9	33.3	33.3	28.6	33.3	0.0	50.0	25.0
10 to 19	24.2	16.7	42.9	50.0	0.0	12.5	0.0
20 to 29	3.0	0.0	0.0	0.0	0.0	0.0	25.0
30 to 39	6.1	0.0	0.0	16.7	0.0	12.5	0.0
>=40	12.1	16.7	0.0	0.0	100.0	0.0	25.0
Total	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

* Study sample includes only those lesions with a visual % stenosis (by the hospital) greater than 10%.

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

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percent v. 9.2 percent). The same hospitals exhibit extreme patterns as above. In the LMCA, the mean difference between HospVis% and InvestVis% is similar to that between HospVis% and Quant%.

Figures 9-1 and 9-2 display cumulative distributions of percent stenosis by the three measurement techniques for the LMCA and epicardial arteries, respectively. For the LMCA, the hospitals' visual estimate is the highest at every level of stenosis, though the difference from the investigator's visual estimates is small for lesions of 80 percent or greater. The quantitative angiographic estimate is lowest at every level of stenosis, and the investigator's visual estimate is intermediate. The proportion of lesions with 50 percent stenosis or greater is 27.2 percent by Quant%, 33.4 percent by InvestVis percent, and 48.6 percent for HospVis percent. Hence, more than 20 percent of patients would be deemed to have "critical" lesions by the hospital than by quantitative angiography.

Findings in epicardial arteries are similar except the difference between HospVis percent and InvestVis percent are much smaller throughout than in the case of the LMCA. The proportion of lesions with 70 percent stenosis or greater is 53.3 percent by Quant percent, 71.3 percent by InvestVis percent, and 77.5 percent by HospVis percent. The implication is that 24.2 percent more lesions would be deemed to have "critical" stenoses by the hospitals' estimates.

9.5.5 Differences Among Measurement Techniques According to the Severity of Stenosis

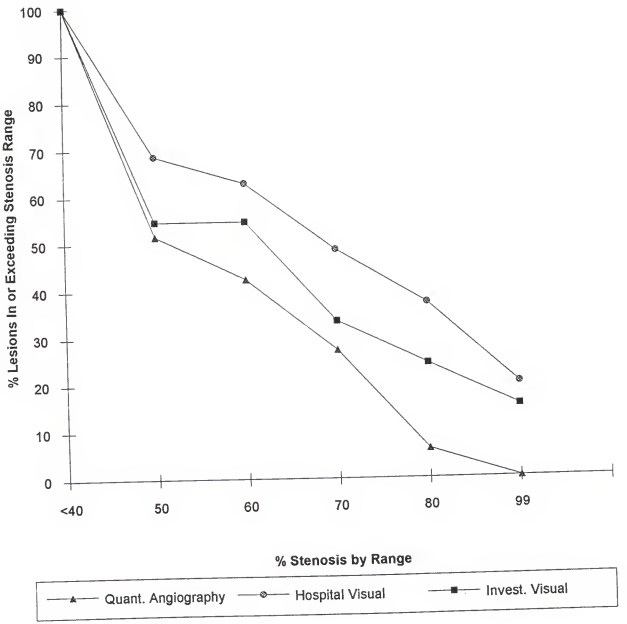
Tables 9-9 and 9-10 examine relationships between (HospVis percent - Quant percent) and (HospVis percent - Invest percent) , respectively, and the degree of stenosis estimated by quantitative angiography. In the epicardial arteries, hospitals' visual estimates show a graded relationship to the extent of stenosis for both comparisons. For HospVis percent - Quant percent (Table 9-9) the mean difference falls from 25 percent when the degree of stenosis by quantitative angiography is <-40 percent, to 13.6 to 15.1 percent range when it is 40 - 69 percent, and to 8.5 percent when it is 70 - 79 percent. Differences become negative for stenoses of 80 - 99 percent indicating higher estimates by quantitative and investigator visual estimates at high levels of obstruction. Median differences followed similar patterns. For HospVis% - InvestVis% (Table 9-10) mean differences are smaller but show essentially the same trend on the LMCA, patterns are similar.

9.5.6 Decision to Bypass a Lesion Versus the Severity of Stenosis

The decision to bypass a particular lesion at the time of CABG surgery depends on the severity of the stenotic lesion by angiography or as it appears at surgery, the clinical condition

FIGURE 9-1

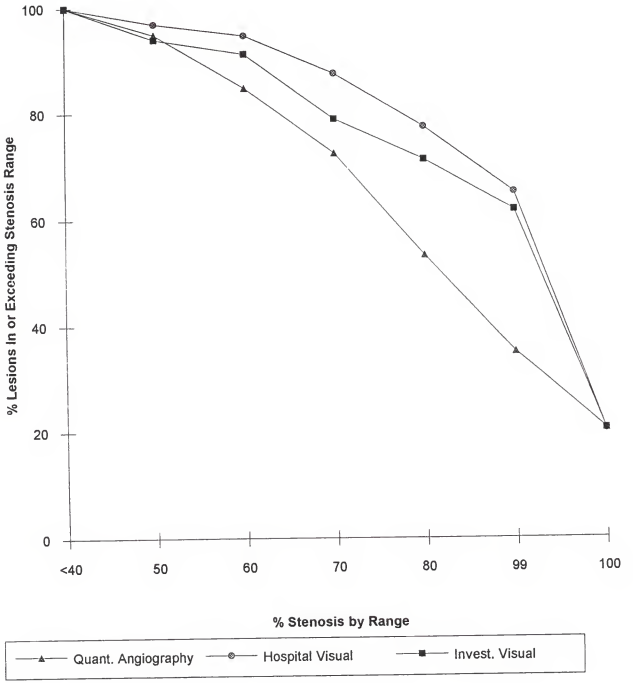
CUMULATIVE DISTRIBUTIONS OF PERCENT STENOSIS OF LESIONS IN THE LMCA FOR DIFFERENT MEASUREMENT TECHNIQUES



heart\tables\FIG9-1.XLS Chart 1\nd

FIGURE 9-2

CUMULATIVE DISTRIBUTIONS OF THE PERCENT STENOSIS IN LESIONS IN EPICARDIAL ARTERIES FOR DIFFERENT MEASUREMENT TECHNIQUES



heart\tables\FIG9-2.XLS Chart 3\nd

TABLE 9-9

DIFFERENCES IN PERCENT STENOSIS BETWEEN HOSPITAL VISUAL AND QUANTITATIVE ANGIOGRAPHY ESTIMATES VS. PERCENT STENOSIS BY QUANTITATIVE ANGIOGRAPHY

	<40	40 TO 49	50 TO 59	60 TO 69	70 TO 79	80 TO 99	Total Occlusion	Totals
EPICARDIAL ARTERIES								
Number of lesions	16	32	39	61	58	46	65	317
Missing	-	-	-	-	-	-	-	3
Mean difference	31.8 %	17.0 %	15.1 %	14.0 %	8.5 %	-1.8 %	0.0 %	9.2 %
Std. Error	4.2	3.3	2.7	1.9	2.1	2.4	0.0	0.9
Median difference	34.7	15.6	15.4	18.2	13.3	3.3	0.0	7.9
<(-20)	0.0	0.3	0.3	0.3	1.6	1.6	0.0	4.1
(-20) to (-11)	0.3	0.6	0.6	1.3	1.3	1.9	0.0	6.0
(-10) to (-1)	0.0	0.6	1.3	2.2	1.3	1.9	0.0	7.3
0 to 9	0.3	2.2	2.5	2.8	2.8	7.3	20.5	38.5
10 to 19	0.0	1.9	2.2	4.1	7.9	1.9	0.0	18.0
20 to 29	1.0	1.9	2.8	7.6	3.5	0.0	0.0	16.7
30 to 39	1.9	1.6	2.2	1.0	0.0	0.0	0.0	6.6
>=40	1.6	1.0	0.3	0.0	0.0	0.0	0.0	2.8
Total	5.1 %	10.1 %	12.3 %	19.3 %	18.3 %	14.5 %	20.5 %	100.0 %
LEFT MAIN CORONARY ARTERY								
Number of lesions	16	3	5	7	2	0	0	33
Missing	-	-	-	-	-	-	-	2
Mean difference	18.9 %	5.5 %	3.0 %	6.9 %	-0.1 %	0.0 %	0.0 %	11.9 %
Std. Error	6.5	2.5	11.6	6.8	7.3	0.0	0.0	4.6
Median difference	12.8	5.0	7.1	8.1	-0.8	0.0	0.0	10.0
<(-20)	0.0	0.0	3.0	0.0	0.0	0.0	0.0	3.0
(-20) to (-11)	6.1	0.0	0.0	6.1	0.0	0.0	0.0	12.1
(-10) to (-1)	6.1	0.0	6.1	6.1	3.0	0.0	0.0	21.2
0 to 9	3.0	3.0	0.0	3.0	3.0	0.0	0.0	12.1
10 to 19	0.0	0.0	3.0	6.1	0.0	0.0	0.0	9.1
20 to 29	15.2	6.1	3.0	0.0	0.0	0.0	0.0	24.2
30 to 39	6.1	0.0	0.0	0.0	0.0	0.0	0.0	6.1
>=40	12.1	0.0	0.0	0.0	0.0	0.0	0.0	12.1
Total	48.5 %	9.1 %	15.2 %	21.2 %	6.1 %	0.0 %	0.0 %	100.0 %

*Study sample includes only those lesions with a visual % stenosis (by the hospital) greater than 10%.

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

TABLE 9-10

DIFFERENCES IN PERCENT STENOSIS BETWEEN HOSPITAL VISUAL AND INVESTIGATOR ESTIMATIONS VS. QUANTITATIVE ESTIMATION OF PERCENT STENOSIS

Difference %	<40	40 TO 49	50 TO 59	60 TO 69	70 TO 79	80 TO 99	Total Occlusion	Totals
EPICARDIAL ARTERIES								
Number of lesions	16	32	39	61	58	46	65	317
Missing	-	-	-	-	-	-	-	3.0
Mean difference	22.1 %	18.4 %	9.7 %	7.0 %	0.1 %	-7.0 %	0.0 %	4.6 %
STd. Error	5.1	3.2	2.7	2.0	2.1	2.4	0.0	0.9
Median difference	26.8	17.5	10.0	10.0	3.3	-4.0	0.0	0.0
<(-20)	0.0	0.0	0.3	1.0	1.9	1.9	0.0	5.1
(-20) to (-11)	0.6	0.3	0.3	0.6	1.6	0.3	0.0	3.8
(-10) to (-1)	0.3	0.6	1.9	2.5	2.5	6.0	0.0	13.9
0 to 9	0.0	1.9	3.2	5.4	6.9	5.4	20.5	43.2
10 to 19	1.0	2.2	2.5	5.1	4.1	0.6	0.0	15.5
20 to 29	0.6	2.2	2.8	3.8	1.3	0.0	0.0	10.7
30 to 39	1.0	1.3	0.6	0.3	0.0	0.3	0.0	3.5
>=40	1.6	1.6	0.6	0.6	0.0	0.0	0.0	4.4
Total	5.1 %	10.1 %	12.3 %	19.3 %	18.3 %	14.5 %	20.5 %	100.0 %
LEFT MAIN CORONARY ARTERY								
Number of lesions	16	3	5	7	2	0	0	33
Missing	-	-	-	-	-	-	-	2.0
Mean difference	24.8 %	13.3 %	-2.5 %	-3.3 %	-5.0 %	0.0 %	0.0 %	11.6 %
Std. Error	7.3	6.7	9.1	5.2	5.0	0.0	0.0	4.0
Median difference	20.0	20.0	-7.5	-10.0	-5.0	0.0	0.0	9.4
<(-20)	3.0	0.0	3.0	3.0	0.0	0.0	0.0	9.1
(-20) to (-11)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(-10) to (-1)	6.1	0.0	3.0	0.0	3.0	0.0	0.0	12.1
0 to 9	9.1	9.1	3.0	9.1	3.0	0.0	0.0	33.3
10 to 19	15.2	0.0	3.0	6.1	0.0	0.0	0.0	24.2
20 to 29	3.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
30 to 39	0.0	0.0	3.0	3.0	0.0	0.0	0.0	6.1
>=40	12.1	0.0	0.0	0.0	0.0	0.0	0.0	12.1
Total	48.5 %	9.1 %	15.2 %	21.2 %	6.1 %	0.0 %	0.0 %	100.0 %

* Study sample includes only those lesions with a visual % stenosis (by the hospital) greater than 10%.

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

of the patient, and the availability of suitable venous or arterial grafts. Though the decision is multifactored, angiographic results play a major role.

Table 9-11 presents data, overall and by hospital, on the relationship between percent stenosis and whether the lesion was bypassed in epicardial arteries. "Innocent bystander" lesions in the LAD were excluded if a LMCA lesion was bypassed.

Hospital visual interpretations are those that guide decision-making. Overall, 90 percent or more of lesions were bypassed if obstructions were 50 percent or more. Nearly two-thirds of lesions with 50-59 percent stenosis were bypassed, and 50 percent or more of lesions with less than 50 percent stenosis. Only 83 percent of totally obstructed arteries were bypassed, probably due to small distal luminal diameters or poor runoffs. Patterns varied widely among hospitals. Hospitals (II, IV, and VI) bypassed nearly all lesions, while Hospital (V) bypassed only three quarters of all lesions.

Results for quantitative angiography reflect the lower percent stenosis recorded by this technique in the range that govern clinical decision-making (40-70 percent). For example, two-thirds of lesions with stenoses of <10 percent to 49 percent by quantitative angiography were bypassed, and 89 percent of lesions with stenoses of 50-59 percent were bypassed.

9.5.7 Effects of Angiography Techniques on Differences Between Hospital Visual and Quantitative Estimates

Table 9-12 presents findings for cineangiogram quality, catheter size, and vessel diameter. The incidence of positive differences 20 percent or greater is markedly lower when the angiogram is of excellent quality compared to poor quality (12.5 percent v. 28.6 percent). Similarly, the incidence of negative differences of 11 percent or greater is also higher for this comparison (4.2 percent v. 11.2 percent). These findings persist for positive differences of 20 percent or greater when the combination of excellent plus good angiograms is compared to average plus poor angiograms (25.8 percent v. 48.6 percent) but are small for negative differences of (14.0 percent v. 16.1 percent).

Use of larger catheters (7F or 8F) appear to be associated with fewer large positive discrepancies (21.4 percent v. 33.9 percent) but more negative discrepancies (14.3 percent v. 3.3 percent) than when smaller catheters are used (5F or 6F).

The distribution of minimum luminal diameters is too skewed toward lesions of less than 2 mm to draw meaningful conclusions (233 of 256 total lesions had MLD of <2mm). An analysis distinguishing lesions of 1 mm and 2 mm is needed. Findings with respect to average luminal diameter are inconclusive. Smaller (<2mm) and larger (>=3mm) show similar patterns of positive and negative discrepancies.

TABLE 9-11

PERCENT STENOSIS OF EPICARDIAL ARTERIES BY HOSPITAL VISUAL AND QUANTITATIVE ANGIOGRAPHIC INTERPRETATIONS VERSUS WHETHER THE LESION WAS BYPASSED AT SURGERY

			HOSPITAL											
	Total		I		II		III		IV		V		VI	
Percent Stenosis	N	Bypass %	N	Bypass %	N	Bypass %	N	Bypass %	N	Bypass %	N	Bypass %	N	Bypass %
Quantitative Angiography														
<40	16	75.0	6	66.7	1	100.0	1	100.0	2	100	3	100	3	33.33
40 to 49	31	67.7	6	83.3	4	75.0	5	40.0	5	100	8	62.5	3	33.33
50 to 59	35	88.6	6	83.3	3	100.0	5	100.0	7	100	8	75	6	83.33
60 to 69	58	89.7	11	90.9	6	83.3	5	100.0	15	93.33	10	80	11	90.91
70 to 79	54	96.3	10	100.0	9	100.0	13	100.0	4	100	6	66.67	12	100
80 to 99	44	100.0	4	100.0	17	100.0	5	100.0	7	100	4	100	7	100
100	64	82.8	7	85.7	12	100.0	11	54.6	11	100	16	68.75	7	100
Total	302	87.8 %	50	88.0 %	52	96.2 %	45	82.2 %	51	98.04 %	55	74.55 %	60	87.76 %
Hospital Visual Interpretation														
<40	8	50.0	1	100.0	1	0.0	0	0.0	0	0.0	4	75.0	2	0.0
40 to 49	5	60.0	0	0.0	3	100.0	1	0.0	0	0.0	0	0.0	1	0.0
50 to 59	22	63.6	2	50.0	7	85.7	5	80.0	2	100.0	1	0.0	5	20.0
60 to 69	31	90.3	6	100.0	4	100.0	6	83.3	3	100.0	8	75.0	4	100.0
70 to 79	36	91.7	9	77.8	7	100.0	8	87.5	7	100.0	0	0.0	5	100.0
80 to 99	139	94.2	25	92.0	19	100.0	15	100.0	28	96.4	26	80.8	26	100.0
100	64	82.8	7	85.7	12	100.0	11	54.6	11	100.0	16	68.8	7	100.0
Total	305	87.2 %	50	88.0 %	53	96.2 %	46	80.4 %	51	98.0 %	55	74.6 %	50	86.0 %

* Study Sample includes only those lesions with a visual % stenosis (by the hospital) greater than 10%

** Study Sample excludes lesions of the left epicardial artery where the patient had a left main coronary artery lesion greater than 50%.

Source: Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration.

TABLE 9-12

DIFFERENCES BETWEEN HOSPITAL VISUAL AND QUANTITATIVE ANGIOGRAPHY ESTIMATIONS VS ANGIOGRAPHY CHARACTERISTICS

CHARACTERISTIC	< (-20)	(-20) to (-11)	(-10) to 0	0 to 9	10 to 19	20 to 29	30 to 39	>=40	N	Total
Angiographic Quality										
Excellent	4.2	0.0	8.3	41.7	33.3	8.3	4.2	0.0	24	7.6
Good	4.4	11.6	4.4	33.3	15.9	20.3	5.8	4.4	69	21.8
Average	3.7	4.4	8.7	41.0	16.8	14.9	8.1	2.5	161	50.8
Poor	4.8	6.4	6.4	36.5	17.5	20.6	4.8	3.2	63	19.9
Catheter Size										
5, 6 F	0.8	2.5	6.6	33.1	23.1	27.3	5.8	0.8	121	38.2
7, 8 F	6.1	8.2	7.7	41.8	14.8	10.2	7.1	4.1	196	61.8
Minimum Luminal Diameter (mm)										
<2	5.2	6.9	9.4	24.5	23.2	21.5	7.3	2.2	233	91.7
2 to 3	7.1	21.4	0.0	14.3	14.3	7.1	21.4	14.3	14	5.5
>3	0.0	0.0	14.3	0.0	14.3	28.6	14.3	28.6	7	2.8
Average Luminal Diamenter (mm)										
<2	4.6	6.1	7.6	21.2	30.3	24.2	3.0	3.0	66	26.0
2 to 3	4.5	9.7	10.5	22.4	18.7	23.1	9.0	2.2	134	52.8
4	9.3	2.3	4.7	30.2	20.9	9.3	16.3	7.0	43	16.9
> 4	0.0	9.1	18.2	18.2	27.3	18.2	0.0	9.1	11	4.3

Source. Based on 119 films provided in 1993 by six hospitals participating in the Medicare Heart Bypass Demonstration

9.6 Multivariate Results

Multivariate analysis-of-variance methods was used to test for differences between the stenosis estimates of cardiologists at the six demonstration hospitals and the quantitative angiography and visual estimates of the expert who reevaluated the angiographic films. Two dependent variables were constructed based on (a) the difference between the hospital's reported levels of stenosis and quantitative angiographic estimates (hospital vs. quantitative difference); and (b) the difference between the hospitals' estimates and an expert's visual estimates (hospital vs. visual investigator difference).

The primary focus of the analysis is on the extent of systematic differences between the hospital and evaluator interpretations of stenosis. In order words, does the average difference in stenosis readings vary systematically from hospital to hospital, implying that some cardiologists in facilities tend to "see" more stenosis than other sites.

Analysis-of-variance methods were used to test the null hypothesis of no systematic differences in readings across the six hospitals. Dummy variables were created for each hospital, and the percent of variance explained by the set of dummies was determined. Joint F-tests were used to determine whether the separation of the readings into six hospital sets explained a statistically significant amount of the variation. Hospital regression coefficients were estimated showing the mean absolute differences in readings between the hospital's and expert interpretations.

To allow for the possibility that systematic errors in interpretation may be affected by other patient variables, several were controlled for, including

* artery system (left, right, circumflex, or left main coronary artery);
* clinical presentation (stable angina, unstable, angina, AMI, or asymptomatic);
* admission priority (elective, urgent, emergent);
* sex (male, female);
* previous CABG;
* patient age;
* percent stenosis.

It is possible that the location of the lesion, the extent of stenosis, or other factors may affect the ability of interpreters to accurately measure the degree of stenosis. The "gold standard" for percent stenosis was the quantitative angiography reading.

Analyses of variance were conducted on all epicardial arteries as a group and then on a pooled sample that included the left main coronary artery. Two models were estimated on

each dependent variable. The first analysis included all potentially confounding variables in evaluating differences across hospitals. This is the most powerful test of hospital differences since it controls for all other possible explanations of systematic differences. However, because of extensive collinearity among potentially confounding variables, it may not be possible to derive accurate estimates of the individual effects. Hence, a deleted model was run in each case based on variables found to be statistically significant (at 10%) in the complete model. The full set of hospital dummies was also included in the second model.

Table 9-13 presents the results of eight models. The first set of four models explain differences in interpretation for lesions in the epicardial arteries alone. For this analysis, complete data were available on 279 lesions. More observations were available in the reduced models due to unreported data. The second four models are based on all arteries including left main stenosis. This sample is larger and includes 309 lesions with complete data.

In Model 1 that compares the hospital's interpretation with the quantitative interpretation, Type I sums of squares (not shown) indicated that hospital site was significantly related to mean differences before any other variables were controlled for ($F = 12.8$, $p<.01$). Type III sums of squares, however, showed a major reduction in the explanatory power of site once all other confounding factors were included. Nevertheless, site remained a highly significant predictor ($F = 5.5$, $p<.01$).

Turning to the coefficients reported in the table, *ceteris paribus*, Hospital I (in the intercept) had a mean overestimate of the degree of stenosis by 34.2 percentage points. (The overall average overestimate vs. quantitative angiography was 8.7 points.) Two hospitals exhibited significantly lower differences: Hospital II was nearly 14 points lower than Hospital I; and Hospital III was almost 8 points lower. The other three institutions were 1-4 points lower, but their difference was not statistically different from Hospital I.

Of patient-level variables, only percent stenosis was found to be significantly related to the differences between hospital and quantitative interpretations. Its coefficient of -.34 ($p<.01$) implies that every 10 percentage point increase in the degree of stenosis resulted in an improvement in hospital accuracy (relative to quantitative angiography) of 3.4 percentage points. Greater error occurred when the degree of stenosis was less. Both a squared stenosis term and categorical stenosis terms were included to test for a nonlinear relationship. The squared term was quite insignificant, implying a linear relationship throughout the relevant range of stenosis. An interaction of hospital site with percent stenosis was insignificant ($F=0.95$; $p=.45$), implying that, in general, sites did not experience different gradients with respect to degree of stenosis. If anything, hospital I showed a greater overestimate, *ceteris paribus*, allowing for different slopes by site.

TABLE 9-13

POOLED REGRESSION RESULTS OF PATIENT VARIABLES AND HOSPITAL ON DIFFERENCES BETWEEN HOSPITAL, QUANTITATIVE, AND EXPERT VISUAL INTERPRETATIONS OF PERCENT STENOSIS

	EPICARDIAL ARTERY LESIONS				COMBINED LEFT MAIN AND EPICARDIAL ARTERY LESIONS			
	Hospital vs. Quantitative		Hospital vs. Investigator		Hospital vs. Quantitative		Hospital vs. Investigator	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Variable								
Intercept (I)	34.24 **	39.26 **	39.40 **	28.84 **	22.84 **	27.97 **	30.37 **	25.55 **
(II)	-13.92 **	-15.59 **	-10.96 **	-13.30 **	-12.27 **	-13.57 **	-10.13 **	-12.03 **
(III)	-7.94 **	-8.90 **	-4.01	-5.32 *	-4.98	-6.43 **	-2.78	-4.04
(IV)	-1.79	-1.48	1.17	1.86	0.02	0.91	2.45	3.66
(V)	-1.39	2.17	0.78	0.19	-0.64	-1.83	-0.35	-0.76
(VI)	-4.21	-5.81 **	5.31	1.29	-3.59	-4.68	6.21 *	2.55
left artery system	1.84		-1.60		10.30 **	10.92 **	4.42	4.24
circumflex artery system	-0.03		-0.73		8.29 **	9.07 **	5.01	4.97
right artery system	-		-		8.47 **	9.09 **	6.03 *	5.77 *
elective procedure	1.42		-1.77		3.30		0.33	
urgent procedure	0.06		-2.87		1.42		-0.87	
male patient	2.69		1.32		2.54		0.71	
stable angina	-4.14		-11.50		-2.39		-8.34	
unstable angina	-0.73		-5.53		0.19		-2.95	
AMI	-0.38		-6.45		1.37		-2.96	
no previous cabg	-3.06		-4.28		-3.55		-5.16	
% stenosis	-0.34 **	-0.34 **	-0.30 **	-0.30 **	-0.33 **	-0.34 **	-0.33 **	-0.33 **
age	0.07		-0.01		-0.06		0.03	
R-squared	0.33	0.32	0.30	0.28	0.30	0.29	0.30	0.29
Number of Cases	279	282	279	282	309	313	309	313
Mean	8.70	8.73	4.12	4.20	8.65	8.69	4.40	4.58

** indicates P-value is <.05

* indicates P-value is < 10

SOURCE: Based on angiographic films and reports provided by six demonstration hospitals, 1993.

Dropping all insignificant variables and rerunning the analysis of variance (see Model 2) resulted in slight increases in the differences between Hospital I (in the intercept) and the other hospitals. Hospital VI became significantly lower (-5.87 points) versus Hospital I. The stenosis coefficient was unaffected.

The results for Models 3 and 4 comparing the hospital's visual interpretation with the expert's own visual interpretation are similar. The F-tests for hospital site and percent stenosis were still significant at the 1 percent level. It should be noted, however, that the mean difference has fallen from 8.70 to 4.12 percentage points. Hospital I continues to have a relatively high overestimate of stenosis (39.40 points) compared to one other site, controlling for degree of stenosis and other factors. After insignificant variables are excluded, however, the intercept coefficient falls below its value in Model 2. Hospital II continues to understate the degree of stenosis significantly relative to Hospital I (by 10.96 points in Model 3 and 13.30 points in Model 4). Except in Model 4, Hospital III and the other three hospitals were not significantly different from Hospital I using tne expert visual standard. The level of stenosis had smaller quantitative effects on the error in Models 3 and 4 but still its coefficient was quite significant. Hospital site-stenosis interactions were statistically significant (p=.07) but are not reported as they had no effect on the basic conclusions.

Results including the left main coronary artery are reported in Models 5-8 in Table 9-6. The results are very similar compared to those based on other arterial groups. In Model 5, Hospital I tended to overestimate the degree of stenosis by roughly 23 points. Hospital II tended to overestimate stenosis by 12 points less than Hospital I while all other hospitals overestimated by about as much as Hospital I.

According to Model 5, hospitals tended to overestimate the degree of stenosis in the epicardial arteries by 8-10 percentage points relative to the left main artery (in the intercept). The degree of stenosis continued to exhibit a highly significant, negative, relationship.

The reduced Model 6 produced only minor changes in the hospital and system coefficients. Hospital III now shows a 6.4-point (lower) difference relative to Hospital I.

Interhospital differences are reduced somewhat when the hospitals' and expert's visual estimates are compared. Hospital III no longer significantly underestimates stenosis relative to Hospital I. Limited evidence suggests Hospital VI may overestimate stenosis relative to I, although this difference disappears in the reduced Model 8. When comparing hospital visual with investigator visual interpretations, only right artery stenosis tended to be overestimated consistently compared to the left main.

9.7 Conclusions

1. The random sample of patients whose cineangiograms were evaluated by quantitative angiography was approximately of the universe of patients operated upon in 1993 in the demonstration.

2. Many cardiac catheterization reports are incomplete with respect to clinical indications for the catheterization and data relevant to the procedure. These data may be recorded elsewhere in the patient's chart, but they need to be readily available to evaluate the risks and costs of the procedure, and, in some cases, to interpret the cineangiogram.

3. Angiographic quality was poor in a substantial (5 - 35 percent) of cases. The fact that quality of the film was associated with the magnitude of discrepancies between the hospitals' interpretations and quantitative angiographic estimates underscores the importance of greater attention to angiographic quality.

4. The hospitals' estimates of the percent stenosis are greater than quantitative angiographic estimates at all levels of stenosis in both the LMCA and epicardial arteries. Differences become smaller, however, at higher degrees of stenosis. The mean percent difference, though not the distribution of lesions among stenosis ranges, actually becomes negative in the 80-99 percent range. In epicardial arteries, 24.2 percent more lesions are classified as having "critical" stenoses of 70 percent or greater by the hospitals' interpretations than by quantitative angiography. In the LMCA, this figure for "critical" lesions greater than 50 percent is 21.4 percent.

5. Hospital visual estimates of the percent stenosis are also greater than expert visual estimates. Differences are less, however, than for quantitative angiography. In the epicardial arteries, 6.2 percent more lesions have "critical" stenoses by hospitals' estimates, and, in the LMCA, this figure is 15.2 percent.

6. Multivariate regressions find that hospital site is significantly associated with differences between hospital visual and quantitative angiographic estimates and also with differences between hospital visual and investigator visual estimates. Of the six hospitals that provided films, one systematically understated the degree of stenosis. Among the rest, three systematically overstated the degree of stenosis while two others were 5-8 points lower depending on whether a quantitative or visual gold standard was used. Percent

stenosis by quantitative angiography is negatively associated with the magnitude of the difference. Overestimations of the percent stenosis are greater for epicardial lesions than they are for LMCA lesions. Other patient variables do not explain significant amounts of the variance.

10.0 CASE STUDY OF CHANGES IN PATIENT MANAGEMENT

10.1 Introduction

Changes in patient management patterns were striking during the period of the Heart Bypass Center Demonstration. There is no question that these changes were heavily influenced by the financial incentives created by bundled payment. They cannot be solely attributed to the demonstration, however, in view of other profound changes that were occurring simultaneously in the organization and financing of medical care.

Three messages came through very clearly from our discussions with the staffs of demonstration hospitals. One was that awareness of the importance of costs was markedly stimulated. In some hospitals, this was a "wake-up call"; in others it reflected a heightened stimulus to previous initiatives. Three of four hospitals hired a consultant to help them identify opportunities to achieve cost efficiencies. This consultant, by presenting data from "leader" institutions, gave their clients the "courage" to make the changes needed to cut costs.

A second message was that the demonstration increased interactions between health professionals and administrative personnel. The perception of "being in the same boat" came through loud and clear. The degree of tension associated with these interactions varied from one hospital to another and, within each hospital, over time. Nonetheless, increased sharing and heightened sensitivity to the other's needs were common to all.

Third, and most important, was that patient outcomes remained the primary consideration despite efforts to control costs. Each practice change we observed was closely evaluated in terms of possibly deleterious effects on the patient, and only those that reflected no adverse effects or an improvement in care were adopted. Several changes in practice patterns ran counter to clinicians' "usual way" of conducting business and required wrenching changes in priorities or outlooks. Others required adjustments in the patient's expectations of the system and created the challenges of assuming greater responsibility for recovery after surgery. There was no evidence, however, that any of the changes we observed increased either patient morbidity or mortality.

The goals of this report are to summarize the major trends in practice patterns. Some hospitals were early and vigorous implementers of change; other were slower and more tentative. All hospitals ultimately changed, however, and the basic directions of change were common to all. Individual initiatives are highlighted to illustrate the range of responses.

10.2 Organization of Site Visits

The information was obtained from on-site interviews with key players at the first four demonstration hospitals. An initial site visit in 1991 provided baseline information on the organization of cardiac and cardiac surgical services and practice patterns. Follow-up site visits in Spring, 1994 permitted identification of changes that had occurred.

During each site visit meetings were conducted with the following hospital personnel:

- CEO and Heart Institute Director (when applicable);
- Chief of Cardiothoracic Surgery and at least one other cardiac surgeon;
- Chief of Cardiology and the Director of the Cardiac Catheterization Laboratory;
- Lead anesthesiologist for cardiothoracic surgery;
- Director of the SICU;
- Intensivist on the SICU (if present);
- Head nurse on the cardiothoracic surgery floor;
- Clinical nurse specialists;
- Cardiac rehabilitation personnel;
- Cardiac social service staff;
- Director of hospital quality management and utilization review;
- Individual responsible for data collection for the Heart Bypass Demonstration.

Questions to be addressed were sent in advance of the site visits, together with requests for written documentation of key data. The questions that guided our follow-up site visit in Spring, 1994 are provided in Appendix 10.

10.3 Organization of Cardiac Services

The four hospitals differed widely in the size, organization, and complexity of their cardiac surgical programs. St. Joseph's Hospital in Atlanta, GA was at one extreme, and the two university hospitals, University Hospital in Boston, MA and Ohio State University Medical Center in Columbus, OH were at the other.

At St. Joseph's Hospital in Atlanta, 18 cardiac surgeons in 5 different practices and about 100 cardiologists in 38 different practices provide services to patients with coronary artery disease. The interrelationships among physicians within each discipline were complex and central direction had to rely heavily on the director of the Heart Institute and hospital administration. Among physicians, one cardiac surgeon was the influence leader.

Anesthesiology included 18 anesthesiologists who "did hearts" and 11 CRNAs who were intimately involved in cardiac surgery cases. The central role of cardiac surgeons in the demonstration created a special relationship that led to the surgeons receiving a $900 "bonus" per case for contributing to the savings that were achieved. The fact that cardiologists were not involved in this incentive arrangement increased competition between them and the surgeons.

The two university hospitals were much smaller and were organized along more traditional academic medical center models. Responsibility for cardiothoracic surgery and cardiology were vested in geographic full-time department chiefs. Arrangements with other surgeons and cardiologists varied but centered around salaried, full-time physicians. Neither hospital used CRNAs in cardiac surgery. Each chief of cardiac surgery strongly influenced the hospital's responses to the demonstration and the time course and vigor of changes in patient management. Both hospitals emphasized the importance of their training and research missions as complements to clinical care. The multiple roles of these hospitals created both opportunities and challenges to the implementation of change.

St. Joseph's Mercy Hospital in Ann Arbor fell between these extremes, in part because it performs teaching functions at the same time it is primarily a clinical center. The formation of a Michigan Heart and Vascular Institute at St. Joseph's Mercy Hospital early in 1994, illustrates the dramatic organizational changes that are occurring in health care institutions. The MHVI is a limited partnership owned by physicians that is located on the grounds of the medical center. It is funded by vascular and cardiothoracic surgeons and cardiologists and is currently led by cardiologists. Of these groups, cardiology clearly represents the outreach arm into a network of community facilities and practitioners. Patient education is a major goal. A chest pain evaluation unit is an important component that serves as an interface with the community and a triage center for patients with chest pain. Until the time of our site visit, only 18% of patients seen in the center had been admitted including 4% with "enzyme bumps". The net effect of this center on hospital admissions and the inpatient census had yet to be fully evaluated, but both hope and concern were voiced by those we interviewed.

10.4 Hospital Admissions for Cardiac Surgery

The main trends we observed were increased emphasis on same-day admissions for elective CABG surgery and, in one hospital, greater flexibility in accepting patients in transfer from other hospitals for same day or weekend surgery.

None of the hospitals performed same-day surgery on a regular basis at the time of our site visits in 1991. By 1994, same-day surgery was a routine part of practice in all hospitals except Ohio State University Medical Center. The frequency of cases ranged widely from 0-4

per month in University Hospital to 80% of elective cases in St. Joseph's Hospital in Atlanta. In all cases, the patient visits the anesthesiologist and receives pre-admission testing the day before surgery and then comes to the hospital at 5 am the morning of surgery. St. Joseph's Mercy Hospital initially experienced resistance from the hospital and from physicians to the idea of same-day surgery. The rate of same-day admissions has grown rapidly since it was begun in FY 1993, however, and 91 patients received their operations on the day of admission during the first 9 months of FY 1994.

Most hospitals still limit CABG surgery on weekends to emergencies. Only St. Joseph's Hospital in Atlanta has taken proactive steps to encourage weekend surgery. Here, transfers are accepted on Friday afternoon from referring hospitals and a full schedule for one surgical team has been established for Saturdays. This effort by tertiary centers to accommodate sources of referral is bound to increase as competition for cases heats up.

10.5 Pre-Operative Management

10.5.1 Unstable Angina and Acute Myocardial Infarction (DRG 106)

The medical and cardiology services play vital roles in non-elective CABG surgery, especially in patients with unstable angina or acute myocardial infarctions. In these patients, critical decisions involve, first, the decision to perform a cardiac catheterization and coronary angiogram and then the decision on whether medications, angioplasty, or CABG surgery is the appropriate treatment. Cardiologists are the gatekeepers and control both the time course of treatment and the treatment decision. The surgeon is often a consultant, though in many instances decisions represent a consensus between medical and surgical perspectives. Considerable efficiencies can be achieved if diagnostic and treatment decisions are timely and delays in scheduling of the catheterization laboratory or operating room are avoided. Hasty decision-making, on the other hand, may lead to unnecessary risks to patient welfare and inappropriate treatment decisions.

Unstable angina represented nearly half of clinical indications for CABG in the demonstration hospitals, and nearly a quarter of patients were operated upon after acute myocardial infarctions. The "handoff" of patients between cardiology and surgery provided a significant opportunity for reducing length of stay and, at the same time, created a point of tension. In two hospitals, surgeons felt that cardiologists were too aggressive in pursuing angioplasty and were failing to refer patients who would have been better treated by surgery. Delays by cardiologists in performing angiograms and, thereafter, in referring patients to surgery were bones of contention in one hospital. In two others, cardiologists were concerned

about delays in scheduling surgery. In one of these, the opening of a second dedicated cardiac surgery OR ameliorated this problem.

Transfers of patients with unstable angina from other hospitals create special challenges. Many of these patients have persistent angina despite maximal drug therapy and require prompt angiography and invasive therapy. The hospitals appeared to vary widely in their abilities to move quickly on such patients.

Aggressiveness of cardiologists in patients who had had recent myocardial infarctions also varied widely. Between 26% and 90% of such patients are being catheterized prior to discharge in different hospitals. Similarly, the threshold for catheterizing patients in the first few days after their myocardial infarctions varied considerably.

10.5.2 Catherization Procedures

The major change in coronary angiography was in the choice of contrast media. In each case, cost was the driving force. One hospital reduced its use of the more expensive non-ionic media from 70% to 30% with consequent savings of $500,000 per year. Tradeoffs are increased risks of nepthrotoxicity and allergic reactions. Non-ionic agents are still preferred in all patients with elevated serum creatinines or a past history of untoward reactions to ionic agents.

Stents are used with varying aggressiveness. The prevailing view in two hospitals was to reserve them for "bale-out" situations. Other hospitals are beginning to use them to maintain patency after angioplasty.

Electrophysiologic procedures (EP) are growing rapidly in three of the four hospitals. The fourth hospital was just initiating its program.

10.5.3 Angioplasty Standby Protocols

In 1991, the universal statement was that an OR and surgeon were on standby for all angioplasties. By 1994, these protocols had been liberalized considerably, in part because of the high cost of a full standby and, in part, because of the low incidence of catastrophes. One hospital stated that it had had no emergencies after angioplasty in 2 years. Current policies take two complementary approaches. The more common practice is to have changed from full standby to a surgeon on call. In this case, an OR is usually available within one hour. The alternative has been to reserve an OR only in high risk patients (about 10% of all patients). The consensus is that the lower intensity approaches increase the efficiencies of catheterization laboratories, ORs, and surgeons alike with minimal downside added risks for the patient.

10.6 Intra-Operative Management

10.6.1 Organization of the Surgical Team

Efforts have centered on increasing efficiency through the use of dedicated cardiothoracic surgical teams and the substitution of a physician assistant for a second surgeon. St. Joseph's Mercy Hospital was especially successful in implementing these staffing changes and, in the past 2 years, has achieved a reduction in the duration of 3-4 bypass graft operations from 4 hours to 3 hours and of CABG redos from 8 hours to 6 hours. Ohio State University Hospitals resisted similar changes because of dedication to teaching and the involvement of residents and fellows in cases.

OR turnover time received considerable attention in three of four hospitals. An important point that was made is that the critical variable is the time that elapses from when the patient leaves the OR until the next patient's procedure actually begins. Readiness of the OR to receive the next patient is an intermediate variable, but not the primary determinant of more efficient OR use. Turnover times of 30 minutes were reported to be achievable.

10.6.2 Choice of Medications

By far the most attention was focused on the choice of anesthetic agent and reducing the duration of its effects after completion of the operation. Some hospitals also made changes in the use of muscle relaxants, vasodilators, and prophylactic antibiotics.

The major issue in anesthesia has been the tradeoffs between continuing use of the brand name drug, Sufenta, or substituting the much less expensive generic drug, fentenyl. The former has the advantage of a shorter half-life and, hence, reduced duration of sedation after the operation. Its disadvantage is 6 times greater cost. Hospitals have responded in two different ways. Three hospitals were successful in encouraging their anesthesiologists to switch from Sufenta to fentenyl with dollar savings of from $100,000 to $250,000 annually. The longer half-life of fentenyl was dealt with by careful attention to reducing doses. The other hospital resisted a change in agent but has achieved some economies by reducing doses of Sufenta.

Other changes in medications included using nitroglycerin as a vasodilator rather than the more expensive regitine and relying on generic rather than brand name muscle relaxants and prophylactic antibiotics.

10.6.3 Standardization of Protocols and Supplies

Tradition has been for hospitals to give free reign to surgeons in their choices of surgical instruments, content and use of surgical packages, valve prostheses or graft materials, and the types of volume expanders or cardioplegic solutions they use. The directions of change has been toward greater standardization of equipment, supplies, and protocols and toward emphasis on reduced wastage of supplies such as surgical sutures and catheters. All vendors and ultimate decisions are now routed through a single surgeon in two of the four hospitals.

Examples are provided by:

1. Standardization of cardioplegic solutions - one hospital reduced from 13 to a single type of solution but allows substitution of other solutions if the surgeon demands it. The end result has been considerable success in substituting Lactex ($6/bag) for Hespan ($50/bag).

2. Substitution of generic protamine for the brand name drug given to reverse the anticoagulative effects of heparin while the patient is on cardiopulmonary bypass. This substitution has been largely accepted in two hospitals without evidence of deleterious effects.

10.7 Post-Operative Management

10.7.1 Intensive Care

The main emphasis has been on shortening length of stay on the SICU by achieving earlier extubation of the patient after surgery. Where possible, extubation is now performed on the same day as surgery compared to the previous norm of the following morning. Lighter anesthesia, greater attention to warming the patient after hypothermic bypass, and low dose narcotics are key preconditions. Each hospital has approached earlier extubation cautiously by developing explicit weaning protocols and carefully monitoring outcomes. For example, one hospital started by limiting early extubation to patients less than 75 years of age with normal left ventricular ejection fractions and then gradually expanded indications as its experience increased.

At present, hospitals report that from 10% to as high as 70% of patients can be extubated in the first 8 hours after surgery. At St. Joseph's Hospital in Atlanta, the mean time to extubation has fallen from 10-11 hours to 7-8 hours. Corresponding reductions in SICU length of stay have been impressive; for example, from a mean of 2.8 days in 1988-1990 to 1.5 days at present in the St. Joseph's Mercy Hospital. University Hospital reports that 70% of

patients leave the SICU within 24 hours. Ohio State University Hospitals report that 25% of patients leave the SICU on the first post-operative day and 75% on the second port-operative day. At OSU, all patients have to be ambulatory before leaving the SICU, free of problems with arrhythmia, and be off intravenous drips. Other hospitals rely on step-down telemetry units to manage arrhythmias.

SICU staffing changes have also occurred. The anesthesiologist, surgeon, and nurse play the major roles. In general, the anesthesiologist is involved only during the first hour. A major change has been to substantially reduce the roles of the respiratory therapists and intensivists.

Another emphasis has been on reducing the frequency of blood gas and electrolyte determinations. For example, the frequency of blood gas determinations per case at OSU was reduced from 16 to 8 after a cost efficiency consultant found this hospital to be a high cost outlier on this variable.

10.7.2 Recuperation on the Floors

The most dramatic changes in post-SICU care are the use of critical pathways to guide treatment, delegation of considerable responsibility for follow-up to clinician nurse specialists (CNS); and reduced use of medical consultants.

Formal Critical Pathways have been implemented in three hospitals and are followed implicitly in the fourth. The development and implementation of Critical Pathways was described best by University Hospital. Here the effort was centered initially on cardiothoracic surgery and involved close collaboration between nurses and physicians. Nursing is credited with providing the "glue". A task force was formed in 1991-1992. Objectives were to define day-by-day post-operative treatment goals; implement these; analyze variances including reasons for deviations from targets; and adjust accordingly. Measures of success were defined in terms of patient morbidity, patient satisfaction, cost per case, physician and nurse relationships, and readmission rates. The consensus has been that implementation of critical pathways creates tension but has the very positive effect of encouraging the adoption of new and quicker ways of providing care.

The use of CNSs varies from hospital to hospital. Extreme patterns are exemplified by OSU Hospitals, on the one hand, and by the St. Joseph's Mercy Hospital and St. Joseph's Hospital in Atlanta, on the other. In OSU, two CNS are consulted only on utilization outliers and report to Quality Assurance. Their objectives are to use Critical Pathways to control post-operative excesses in utilization. In St. Joseph's Mercy and St. Joseph's Hospital of Atlanta, CNSs are paid by the hospital but work for cardiothoracic surgery. They round daily on all

patients, write orders, and act as case managers. Floor nurses, in turn, provide routine nursing care, do patient education, and maintain patient charts.

Reduced use of medical consultants was reported in three hospitals. In all three, the cardiologist's role during surgery and follow-up has been virtually eliminated. At St. Joseph's Mercy Hospital, consultants per case fell from 3.6 in 1991 to 2.6 in 1993. At St. Joseph's Hospital in Atlanta, hematology consults fell from 3% to 1.1% of cases between 1991 and 1993 and infectious disease consults from 5.1% to 2.8% of cases. Representatives from consultant specialties complained that they are now being called too late and that patients are much sicker than previously. We were not able to verify these comments.

10.7.3 Discharge Planning

Pressures for earlier discharge require earlier attention to planning, better coordination with family and community services, and, very importantly, adjustments of the patient's and family expectations. Little hard data were available to support claims of success. In at least one hospital, however, patient education is now begun at the time of the pre-admission visit, and the seeds are planted with respect to an expectation of discharge 5 to 7 days post-operatively if the clinical course is uncomplicated.

10.8 Quality Management

10.8.1 Cardiac Data Systems

The capabilities of cardiac registries varied widely both at the beginning of the demonstration in 1991 and in 1994. Three hospitals had established cardiac surgical registries in 1991, but one of these served primarily research purposes. By 1994, databases in the two clinically-oriented sites were being used regularly to monitor outcomes, and significant progress has been noted in all sites during the demonstration.

A major shortcoming has been the failure to link cardiac catheterization laboratory databases to cardiac surgical databases. The result has been the need to reabstract catheterization, non-invasive testing, or EP data for inclusion in the surgical registry with consequent missing or inaccurate data. Furthermore, no hospital linked cardiac surgical data to a hospital clinical database or to financial data.

Long-term follow-up data was collected routinely in only one hospital in 1991 and, then, it was unclear how these data were used to improve the quality of care.

10.8.2 Quality Management

Hospital-wide quality management systems ranged from non-existent to sophisticated (and expensive) continuous monitoring of as many as 20 clinical indicators. OSU Hospitals, in particular, had implemented a system that routinely monitors variables such as inpatient mortality, complication rates, readmission rates, and patient satisfaction and produces quarterly control charts. This system was unable to provide results directly applicable to cardiac surgery, however.

Monitoring of cardiac surgical outcomes within the department was especially impressive in two hospitals. In one, several studies had been completed examining such issues as reoperations for bleeding, use of blood products, and use of laboratory tests including blood gases. In another, monthly reports on upwards of 20 variables were generated and discussed at M and M conferences.

11.0 CASE STUDY FINDINGS: IMPROVEMENTS IN HOSPITAL MANAGEMENT

11.1 Introduction

Quantitative analysis of trends in patient outcomes, lengths of stay, and costs is necessary component of the evaluation of the demonstration. Equally important, however, is gaining a better understanding of the organizational and behavioral changes that underlie the numbers. A demonstration provides more than statistics; it also provides an opportunity to talk with providers about how they responded to the incentives embedded in a single bundled payment. Abstract statistics do not inform policy makers about how lengths of stay were shortened, only that they did fall, nor do statistics tell why costs were reduced in the pharmacy; only that they did. And while statistical analyses can correlate changes in key outcomes with the introduction of the novel global payment arrangement, they do not rule out other possible explanations that only the providers themselves are aware of.

In this chapter, case study findings regarding improvements in hospital-physician management are reported. Personal interviews with hospital managers, their staffs, and physicians were conducted to fill in the missing organizational information on what changes were made, to improve efficiency or why they were not made. Incentives to improve efficiency are fairly clear with a joint payment. First, both the hospital and physicians have incentives to improve the efficiency and reduce the costliness of care to stay within the negotiated global rates. These rates are absolutely fixed under the demonstration with no additional outlier payments, capital passthroughs, etc., that exist in the current Medicare prospective payment system. The second, quite unique, aspect of the demonstration is the alignment of physician with hospital incentives to control costs. How have hospital staffs and physicians responded to the shared incentive to improve efficiency? What evidence is there of a closer working relationship in managing source and costly inpatient resources? Which services have been most amenable to management improvements? Answers to these questions form the basis of this chapter.

11.2 Organization of Interviews

Several hospital managers, key department staff, and physicians were interviewed in each of the four original demonstration hospitals regarding management improvements. Persons interviewed included:

- Chief Financial Officers

- Comptrollers and financial analysts
- Vice-presidents responsible for clinical and institutional care
- Programmers responsible for cost accounting
- Department managers of the ICU, nursing service, operating room, catheter lab, and pharmacy
- Clinical nurse specialists responsible for monitoring demonstration patients
- Thoracic surgeons
- Anesthesiologists, cardiologists, and consulting physicians.

The interviews took place over a two-day period in the Spring of 1994, over thirty months after the hospital and physicians began receiving single bundled payments. This allowed time for the providers to respond to the incentives under a single payment and to implement management changes designed to improve efficiency.

Interview protocols were tailored to the responsibilities of the interviewee. (See Appendix 10.) Broader financial questions on gains and losses were directed to CFOs, comptrollers, and others responsible for setting and managing hospital budgets. Other questions were asked of department heads concerning management efficiencies introduced over the last three years. Clinical staff were asked to describe ways in which patient management had changed that would have implications for costs.

The results reported below reflect the synthesis of all the comments and observations from the more than 50 interviews that touched upon management issues in one way or another. Many findings, it should be noted, do not pertain to all four sites. Where one or two sites differ in response, reasons for the difference are given. Indeed, dissimilar responses to the same set of incentives affords a better understanding of the generalizability of global payment to other sites.

The findings in this chapter are presented in six parts. Systems used in monitoring patient costs and severity of illness are presented first, followed by a discussion of management improvements in the ICU, on the routine nursing floors, in the operating room, in the catheter lab, and in the pharmacy. Although many other departments are called upon to provide services to bypass patients, such as radiology and pulmonology, their role is more tangential with much lower contributions to patient costliness on average (see Chapter 6). Respondents did comment on the use of ancillary services, on the other hand, and their observations are reflected where they apply.

11.3 Systems for Monitoring Costs and Outcomes

Two kinds of data are routinely collected by providers on bypass patients: (1) clinical registry information on patient risk indicators and health outcomes; and (2) micro-cost data on resource use and costs. Clinical data come from both physician and hospital medical records. Few other specialties collect as much detail on their patients as cardiovascular surgeons and cardiologists. Micro-cost data, by contrast, are collected by the hospital finance department for all hospitalized patients. Not only are these data quite detailed, they are available on all patients and not just those with heart disease. For evaluation purposes, their primary limitation is the lack of information on physician inputs beyond the reporting of tests and procedures. These micro-cost systems cover only the costs incurred by the institution, excluding physician practices. Fortunately, having a comprehensive listing of physician-related tests and procedures allows one to track the bulk of physician activities as well.

Of the two data systems, this chapter concentrates on the micro-cost information used by hospitals in evaluating management changes. How was it developed? How has its use changed under the demonstration? The rate of the clinical data set is discussed in Chapter 10 on patient care management.

11.3.1 Implementing a Micro-Cost System

First, what is included in a micro-cost data set? Most researchers are familiar with the Medicare cost reports. These reports summarize direct labor and other costs at the department level and stepdown indirect overhead costs intc departments using appropriate statistical bases, e.g., department square feet, salaries. Medicare cost reports do not report counts of tests, procedures, or other intermediate outputs within departments, unfortunately, except for nursing where patient days are given. Nor do they directly link costs and resource use to specific patients. Micro-cost data sets do report department volumes and individual patient costs. Three of the four original demonstration hospitals have adopted extremely disaggregated micro-cost accounting software that itemizes and costs every service appearing separately on a patient's bill. The fourth hospital uses a less complex costing software that, by their own admission, is less refined but considered adequate for management purposes.

Appendix 11-A gives an example of the level of detail available for these bypass patients. Ten different categories of costs are shown for literally hundreds of different services and drugs, including:

- 4 hours (O.R.) = $449.38
- Swan-Ganz catheter = $70.29

- 4 Chem 20's = $96.34
- 2 Monitor CO2/OXI = $56.24
- 1 STAT EKG = $29.20
- 2 units of IV Heparin 100 = $10.58
- One left heart cath = $254.64
- 8 ICU-East room care days = $1,774.54
- 6 Routine Telemetry days = $649.24 + $146.07

How are these micro-cost systems implemented? Initial calibration and implementation requires extensive hospital resources after purchasing the software. One respondent estimated that upwards of $500,000 could be spent implementing the system over 3-4 years. Initial cost and timeliness are two strong arguments against adopting a full-fledged micro-cost system and certainly put it out of the reach of even middle-sized institutions, unless significantly streamlined. On the other hand, if the system saves only 1% in annual costs, it could pay for itself in the first year in a $50 million institution.

Initial calibration is the most costly and time-consuming. Each department manager is asked to identify the services that comprise, say, 80% of charges. This can be 5 or 50, depending on department. Next, managers and staff are asked to list all of the inputs involved in a test or procedure. For example, one hour in the operating room (code 6000015) has inputs divided into 6.7 professional labor hours at $10.86 average wage per hour, total cost = $61.58, plus nonsalary supplies that include: 1 exam glove ($0.81), 1 sponge count bag ($0.61), 2 suctions ($2.46), 3 syringes ($0.27), 1 bandage roll ($0.09). Total nonsalary expenses = $4.24, which, when added to salary costs, gives $65.82 in procedure costs. This estimate does not include the perfusionist (estimated to cost $619.73 in professional time, cardioplegic solutions, pump tubing, etc.). Nor does it include extra cart supplies required in open heart surgery.

Once each labor and nonlabor input is identified, managers next estimate the labor time and quantities of inputs that go into producing a specific test or procedure. Then, the accounting department applies a unit cost to the average input quantities to derive an estimate of total direct cost for the service. Calibration is eventually done for thousands of services involving hundreds of different inputs. Also as part of calibration, managers must classify each input as variable or fixed. Often, this requires a proration of the input into a fixed and variable component, e.g., floor nurse variable time on a floor vs. head nurse fixed time. The same is done with indirect costs such as dietary, administration, housekeeping, and buildings and equipment, each of which has fixed and variable components. Dividing indirect costs into fixed and variable is a break with past accounting methods that simply treated all indirect costs as fixed; an assumption clearly inappropriate for dietary, housekeeping, and other census

related support services. It should be noted that the four demonstration hospitals differ widely in their fixed-variable allocation algorithms, and interhospital cost comparisons must be made cautiously.

11.3.2 Micro-Cost Versus Cost-Based Accounting Systems

Micro-cost systems were designed to replace traditional cost accounting systems supporting cost-based reimbursement. The latter used crude cost-to-charge ratios to allocate costs to payers based on total charges in each department. Cost-based systems were very misleading regarding true patient costs. First, allocation algorithms could be manipulated in ways to maximize reimbursement that had little to do with real department costs. Second, they never linked costs with individual patients. Payers simply wanted to pay their fair share of overall facility costs for their own patients taken as a group, not for individual patients. Hospital managers became interested in individual patient costing when Medicare prospective payment began paying flat rates on patients within DRGs. This required new, more patient-oriented, allocation systems. Medicare also required a more meaningful distinction between fixed and variable costs. Payments may not cover average total costs per discharge, but managers knew that was not the relevant cost in the short run. Average variable cost was more meaningful. Did a particular patient or product line more than cover its variable costs and contribute towards the fixed costs? If marginal costs were not even covered, then a patient or a whole DRG lowered short-run profits and threatened financial viability.

Micro-cost systems dealt explicitly with both problems by itemizing costs at the micro-service level, classifying costs into fixed and variable, and then linking them with individual patients through the patient billing system. Unbilled indirect services were also classified as to fixed vs. variable and allocated to departments and individual services in various ways.

11.3.3 Using a Micro-Cost System

With this brief overview of micro-cost systems and how they were implemented, what can be said regarding their use in the demonstration hospitals? Based on our interviews, it appears that hospital staff produce few standard micro-cost reports, nor is their a single group that analyzes them. A flexible report writer built into the software allows managers of the data base to respond to requests from department managers. A special run will be given anesthesia, for example, on the frequency and costs of anesthetic agents, or to nursing on ICU lengths of stay, or to the OR Director on operating room times and supplies. The extent of decentralization and lack of overall direction in the use of the micro-cost data, while

unexpected, is probably more effective than a single set of reports so long as delegation of responsibility for controlling costs is clear.

What has been the participants' experience with these systems? Micro-cost reports can be used at two very distinct levels in the hospital. At the CFO level, micro-cost reports track costs, reimbursements, and profitability for demonstration DRG's 106 and 107 taken as whole. It was surprising how little attention in general has been given to such reports. None of the hospital CFO's spent much time monitoring monthly or quarterly financial reports on profits and losses on demonstration patients. Partly, this was due to the lack of an accurate cost accounting as three of the four hospitals either did not have or were just implementing a micro-cost system when the demonstration started. But even in the hospital that already had an operational micro-cost system, review of financial performance was done only annually. Financial managers either do not view monthly reports as representative of longer-run trends due to random variation in patient requirements or that such reports have no immediate management implications beyond targeting a DRG (or department) for detailed analysis. In their annual reviews, however, financial officers did compare actual costs with negotiated payment rates under the demonstration to see how the hospital was doing financially and what the expected gain or loss might be next year with the payment updates.

Early on in the demonstration, managers in three of the four hospitals realized that micro-cost systems alone were inadequate in helping them understand and change physician practice patterns. The strength of these systems, they realized, was not in the "costs" they generated so much as in the resource use statistics underlying costs, e.g., echocardiographs, stress tests, vials of ionic vs. non-ionic contrasts, operating room hours. While some efforts have been made to reduce cost per unit of service, managers realized that the level and mix of services was driving cost differences across patients and over time. They also quickly realized the value of presenting the micro-cost data in a particular way to clinicians who managed patients. First, and most important, they discovered that information on resource use must be patient-specific and capable of being sorted by surgeon. It also must be available in extremely itemized form. The one hospital that did not have a micro-cost system but relied on outdated cost-to-charge methods encountered strong resistance from surgeons who felt they could not respond to "high pharmacy costs" in general without knowing the procedure bundle, to cite one department. To change physician practices, clinicians must be shown exactly which drugs they are using, how many ICU days their patients are incurring, how many suture bags or catheters they are using, all compared to their peers. To tell surgeons that their DRG 106 patients are 15% more costly than their peers is less than helpful; it is antagonistic. The one hospital without itemized detail found surgeons treating the alleged costs as "part of a game" with little validity.

Even with the fine-grained procedure detail, micro-cost systems, by themselves, proved inadequate in convincing physicians to change their practice patterns. When questioned, physicians claimed that their patient mix was different and required more services. Nurses made similar claims about patients admitted to the ICU and routine floors. Similar responses stymied managers in most U.S. hospitals after the first few years of Medicare prospective payment when unnecessary days had been squeezed out and the tough job of reducing intermediate services began. To address the "unique patient mix" argument, all four hospitals contracted with L. Byrne Associates to produce a set of comparative reports on the two demonstration DRGs separately (see Exhibit 11-1). These reports had several strengths: They

(1) provided comparative information on similar hospitals and for the same hospital over quarters;

(2) provided key descriptive patient indicators such as age, percent of patients with at least 3 comorbid conditions, percent with acute AMI, etc.;

(3) provided comparative information on patients organized by surgeon; and they

(4) decomposed costs in more meaningful clinical ways such as length of stay from admission to cath and cath to bypass, etc.

Hospital financial managers did not have the expertise to organize and present their micro-cost information in a way convincing to physicians, but they were wise enough to contract with a group who did. Hospital managers also upgraded their nurse acuity systems and included them in their micro-costing data bases to better evaluate per diem nursing utilization.

A final strength of the "outside contracting" approach was that it kept financial managers at arms length is the discussion of patient management. L. Byrne clinical staff would meet quarterly with physicians to review the data and discuss possible efficiency improvements. In these discussions, consulting staff relied on their experiences in similar institutions. What peers were doing elsewhere carried considerable weight with demonstration physicians. Comparative reports would not have been possible, however, without the micro-costing system and its itemized format linked to patients.

The micro-cost information along with key patient characteristics were used in several important ways to reduce the costs of bypass surgery. Probably most significant was the

EXHIBIT II-1

HOSPITAL COMPARATIVE INFORMATION
DRG #106 CAB w/CATH

		NATIONAL SAMPLE 48 HOSPITALS 1ST QUARTER 1993 RANGE	NATIONAL SAMPLE AVERAGE 1993	Unity Hospital Average	01/92 12/92	01/93 04/93	04/93 06/93	06/93 09/93	CHANGE
1	PATIENTS IN SAMPLE				142	41	27	31	
2	AGE	57.1 - 71.0	66.0	65.2	61.8	63.8	63.9	60.3	-1.5
3	% MEDICARE	49.2% - 65.9%	58.3%	55.1%	45.8%	53.7%	40.7%	51.6%	5.8%
4	% FEMALE	16.5% - 54.9%	29.5%	31.8%	32.4%	29.3%	33.3%	32.3%	-0.1%
5	% ACUTE MI	6.1% - 45.6%	28.4%	29.6%	16.9%	34.1%	29.6%	41.9%	25.0%
6	CM'S / PATIENT	1.5 - 3.8	3.1	3.3	2.3	3.0	2.4	3.0	0.7
7	% PATIENTS WITH >3 CM'S	28.7% - 74.8%	46.3%	49.0%	19.0%	24.4%	18.5%	32.3%	13.3%
8	NO. LEG GRAFTS	2.2 - 3.7	3.2	2.7	2.2	2.3	2.2	2.4	0.2
9	NO. IMA GRAFTS	0.0 - 1.9	0.9	0.8	0.6	0.6	0.6	0.6	0.0
10	% RIGHT & LEFT HEART CATH	2.1% - 78.2%	13.6%	18.2%	8.5%	12.2%	7.4%	6.5%	-2.0%
11	% LEFT HEART CATH	12.7% - 98.5%	86.4%	81.8%	91.5%	87.8%	92.6%	93.5%	2.0%
12	% CATH SAME ADMIT	100.0% - 100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%
13	LENGTH OF STAY (DAYS)								
14	ADMIT TO CATH	0.4 - 3.9	1.0	1.1	1.2	1.2	1.0	1.1	-0.1
15	CATH TO OPEN HEART	0.9 - 4.5	1.9	2.2	3.9	4.4	4.7	4.9	1.0
16	ADMIT TO OPEN HEART	1.6 - 6.1	2.9	3.3	5.1	5.6	5.7	6.0	0.9
17	OPEN HEART TO DISCHARGE	5.6 - 14.4	7.5	7.7	9.2	8.5	8.3	8.3	-0.9
18	TOTAL LENGTH OF STAY	8.6 - 19.9	10.4	11.0	14.3	14.1	14.0	14.3	0.0
19	REG ROOM LOS	0.0 - 7.9	1.6	1.8	4.2	4.1	3.7	4.2	0.0
20	REG ROOM $	$0 - $1,597	$665	$706	$1,120	$1,078	$982	$1,082	($38)
21	REG ROOM $/DAY	$0 - $480	$416	$392	$265	$265	$265	$264	($1)
22	INTERMEDIATE CARE LOS	3.7 - 14.1	6.4	6.3	5.6	5.3	4.0	3.7	-1.9
23	INTERMEDIATE CARE $	$1,147 - $5,210	$3,487	$3,358	$2,972	$2,840	$2,177	$2,048	($924)
24	INTERMEDIATE CARE $/DAY	$302 - $825	$544	$533	$535	$532	$539	$547	$12
25	ICU/CCU LOS	1.0 - 6.7	2.4	2.9	4.5	4.7	6.3	6.4	1.9
26	ICU/CCU $	$709 - $5,682	$2,630	$2,857	$4,251	$4,553	$5,726	$5,914	$1,663
27	ICU/CCU $/DAY	$556 - $1,409	$1,097	$985	$945	$962	$915	$921	($24)
28	TOTAL ROOM & CARE $	$3,097 - $12,263	$6,782	$6,921	$8,143	$8,471	$8,885	$9,044	$701
29	TOTAL ROOM & CARE $/DAY	$351 - $763	$652	$629	$584	$599	$635	$634	$50
30	TOTAL ROOM & CARE %	10.9% - 32.1%	19.9%	21.1%	21.1%	21.4%	22.4%	22.5%	1.4%
31	OPERATING ROOM $	$1,518 - $18,697	$7,490	$7,525	$11,833	$11,139	$10,344	$9,885	($1,948)
32	ANESTHESIA SUPPLIES $	$94 - $2,106	$643	$508	$829	$784	$756	$754	($75)
33	SUPPLIES $	$904 - $14,515	$6,286	$5,414	$3,162	$3,685	$3,611	$3,371	$209
34	TOTAL (OR+ANES+SUPPLIES) $	$2,516 - $35,318	$14,419	$13,447	$15,824	$15,608	$14,711	$14,010	($1,814)
35	TOTAL (OR+ANES+SUPPLIES) %	25.1% - 51.7%	42.3%	41.0%	40.0%	39.5%	37.0%	34.8%	5.2%
36	RADIOLOGY $	$291 - $2,589	$706	$629	$1,053	$1,202	$1,442	$1,346	$293
37	CARDIAC CATH $	$1,280 - $5,863	$2,375	$2,473	$2,278	$2,307	$2,172	$2,010	($268)
38	CARDIAC DIAGNOSIS $	$154 - $892	$527	$494	$567	$551	$643	$493	($74)
39	LAB & BLOOD $	$1,571 - $7,141	$4,110	$4,062	$4,466	$4,649	$5,375	$6,390	$1,924
40	PHARMACY & I.V. $	$1,238 - $7,817	$3,431	$3,116	$4,810	$4,544	$4,883	$5,096	$286
41	RESPIRATORY THERAPY $	$421 - $4,261	$1,392	$1,287	$1,607	$1,811	$1,165	$944	($663)
42	OTHER & MISCELLANEOUS $	$96 - $1,357	$356	$329	$642	$566	$454	$869	$227
43	TOTAL ANCILLARY $	$10,501 - $55,579	$27,314	$25,837	$31,247	$31,038	$30,845	$31,158	($89)
44	TOTAL ANCILLARY %	64.2% - 82.9%	80.1%	78.9%	78.9%	78.6%	77.6%	77.5%	-1.4%
45	TOTAL $/CASE	$16,099 - $66,528	$34,096	$32,758	$39,590	$39,509	$39,730	$40,202	$612
46	OUTLIERS EXCLUDED (%)		5.6%	5.6%	3.4%	4.7%	3.6%	8.8%	
47	OUTLIERS EXCLUDED (#)				5	2	1	3	
48	TOTAL $/CASE W/OUTLIERS				$40,741	$40,657	$40,109	$44,081	

NOTE: RANGE reflects variance between lowest and highest average
NOTE: Outliers per LRA Definition.

decomposition of length of stay into four parts (for DRG 106): (1) admission to catheterization (angiography); (2) catheterization to surgery; (3) post-surgery ICU days; and (4) post-ICU routine nursing days. Each segment involves a different set of diagnostic and therapeutic decisions, a different set of physicians, and a different locus of care within the institution. By breaking down the stay into more clinically meaningful parts, managers and physicians were able to work with the appropriate decision makers in reducing lengths of stay.

Although the outside contractor put the micro-cost data in a form useful in evaluating physician practice patterns, none of the four hospitals ever actually merged it with the clinical data. Each surgical group maintains a detailed clinical data base on risk factors, anatomy of disease, complications, procedures, and outcomes. Were these data merged with information on resource use, hospital managers and physicians could gain a deeper understanding of the factors explaining the variation in costs across patients. Very few risk factors, for example, are displayed in the L. Byrne reports, nor are patients stratified by risk factor and costs and utilization displayed. ICU days per patient may be longer for some surgeons because more of their patients were undergoing their second bypass, or were over 75 years old, or were admitted as emergencies. Each of these factors, we have found, increases lengths of stay (see Chapter 7). Also stratifying lengths of stay and resource use by type of complication would document the cost implications of reducing complication rates. No attempts to merge the data bases have been made, to our knowledge, suggesting that either physicians or hospital management do not see the value in further controlling for severity in explaining resource use. It may be that the overarching incentives to control resource use automatically implies reducing, complication rates, among other things, but the success of even fairly simple reports like those provided by L. Byrne staff point to further gains from using a merged data set.

Nearly all hospital and physician respondents felt that the single bundled payment was critical in encouraging more detailed, accurate, cost reporting so necessary in changing physician practice patterns. Indeed, once a couple of hospitals negotiated bundled discounted rates with HCFA, they accelerated implementation of a micro-cost system. In another instance, when hoped-for volume increases didn't materialize in the demonstration's first year, producing large financial losses, the hospital started to upgrade their costing system and brought in an outside evaluator.

Managers acknowledged that, for the first time, physicians--and surgeons in particular--took an active interest in hospital resource use. In discussions with their peers and with L. Byrne staff, surgeons began reviewing micro-cost printouts and questioning as excessively long ICU stays, the use of very expensive non-ionic contrast agents in catheterization and nonstandard surgical supplies, delays between angiography results and surgery, the use of expensive anesthetic agents, and above all, the use of physician consultants. In three of four

hospitals, physicians were said to be very cooperative in reviewing micro-cost reports and L. Byrne data. Without doubt, having the head surgeon actively involved in reviewing practice patterns and the costs in the operating room, the ICU, and the cath lab, changed the decision-making dynamic. Surgeons are far more effective than untrained hospital financial managers in encouraging their peers to adopt more cost-effectiveness methods. Not only are they intimately familiar with patient needs and true differences in severity, but they become the ultimate decision maker in a patient's care once he/she is scheduled for a bypass. Hospital administrators, in contrast, exert far less leverage or physicians, especially in academic medical centers (which comprised two of the four participants).

Another shift in the decision-making dynamic came from the availability of comparative data. Many surgeons and cardiologists were challenged by their peers in other institutions to become more efficient, to shorten stays, to reduce pharmacy costs, etc. Each quarter, clinicians saw a new "report card" on their performance relative to their peers in similar hospitals. These comparisons built upon the academic aspects of the demonstration just as new findings from clinical trials challenge physicians to practice in different ways. A direct outcome of this challenge was the willingness of most surgeons to support the development of clinical pathways protocols that streamlined patient flow through. (See below for more discussion.)

A fourth hospital was not nearly as successful in changing physician practice patterns primarily because its surgeons have regarded the micro-cost comparisons as an intrusion on their practice. Historically, physicians have been resentful of financial managers telling them how to practice medicine. They are accustomed to having full authority over hospital resource use without any financial responsibility for costs. Although most demonstration hospitals enjoyed a close working relationship with physicians, in the one site where surgeons resisted the concept of comparative costing, the impact of micro-cost reporting on streamlining care was greatly diminished. Claims were made that a surgeon "couldn't use albumin to resuscitate patients" or there were pressures "to reduce suture costs". It was not possible to corroborate such claims, but they typify the thinking of some clinicians when faced with intrusions on their decision-making domain. Resistance to changing practice patterns will remain the single greatest barrier to reducing bypass surgery costs under a natural global payment program. What forces might explain the degree of resistance to change will be discussed in Chapter 13 on hospital-physician relations.

Besides the obvious advantages of the micro-cost system in better managing patients, hospitals are using it to set more efficient department budgets as well. In the past, managers have lacked detailed information on the range and costliness of outputs at the department level, e.g., two-view chest x-rays, head CTs, MRIs. With the micro-cost system, not only are

actual volumes tracked by individual service, they are weighted by resource use. Furthermore, variable costs are distinguished from fixed costs. This allows managers to set prospective budgets based on expected changes, not in overall patient volumes, but department-specific volumes adjusted for both procedure mix and variable costs.

11.4 Overall Staffing Changes

Two of the four demonstration hospitals emphasized their conscious plan to reduce staffing levels. Not by coincidence, both were non-academic institutions. At one facility, full-time-equivalent staff had been reduced by 200 (10-15% of workforce) in the last two years. In the second hospital, the workforce had been reduced by 500 or more FTEs over four years while total hours per adjusted discharge fell from 210 to 165.

Both hospitals used data from other hospitals to evaluate their own staffing levels. FTE target levels were set by area to hold management accountable. It should be remembered that this was also a time of declining inpatient use across the country, accompanied by the spread of managed care and cost cutting pressures. Both hospitals used attrition as a primary way of reducing staff, especially in the nursing area. Both hospitals also focused on the overhead areas in an attempt to reduce top heavy management. One was much more aggressive, however, in eliminating an entire layer of assistant vice-presidents in charge of groups of departments.

11.5 Intensive Care Units

11.5.1 Shorter Stays

Based on interviews with ICU nurses and hospital managers, it appears that the demonstration has led to significant gains in efficiency in post-surgical ICU care. At the beginning of the demonstration in mid-1991, 48-hour ICU stays for uncomplicated patients was the standard protocol. Just two and a half years later, 24 hours is the expected stay for uncomplicated patients. In one hospital, 70-80% of patients were discharged from the ICU within 24 hours as part of an overall stay plan of just 7 days.

Key to shorter ICU stays is early extubation. Protocols in one hospital called for extubation within 8 hours of surgery, accomplished by close monitoring of "drips", bleeding, and other signs of complications. Nevertheless, a few anesthesiologists in two of the hospitals were reluctant to take out tubes until the second ICU day. In most cases, though, physicians seem willing, even anxious, to shorten ICU stays. Some felt that even 24 hours was unnecessary for very simple cases.

One hospital, however, continued to have troubles implementing its ICU protocol with only 25% of patients discharged in 24 hours. Problems occurred in weaning patients from their anesthetic lines due to shivering and occasional seizures. At first, physicians simply aborted the protocol instead of monitoring patient vital signs and continuing weaning. This led to a new protocol for weaning patients. Nurse specialists worked with anesthesiologists to begin warming patients sooner in the operating room to avoid complications that delayed extubation and prevented quicker ICU discharges.

Another key to short ICU stays is early ambulation. Nurses chart the number of feet a patient walks each day and their oxygen intake levels to assure they are ready for the routine nursing ward.

Three of four hospitals adopted some form of clinical pathways implemented by clinical nurse specialists to improve patient flow-through in the ICU as well as elsewhere. ICU staff felt having a single person familiar with the patient throughout their stay helped in making difficult decisions about early transfer to a stepdown unit (see Chapter 10 for more details).

Residents in academic medical centers present special problems in shortening ICU stays. They are less experienced, nurses claim, and tend to overdo testing. Their inexperience also makes them very conservative in discharging to the routine nursing floors. Still, the demonstration and the introduction of nurse specialists has forced all staff, residents included, to rethink standing orders regarding how frequently to draw blood, to do blood gases, etc. Using, L. Byrne data, one hospital was shown to be an extreme outlier in the number of times during an admission blood gases were evaluated. New protocols cut the frequency in half from 16 to 8.

11.5.2 Economies of Scope

Yet another reason for a less costly, more efficient, ICU stay for bypass patients has to do with the concentration of heart patients. One hospital in the demonstration has two critical care ICUs with 51 beds and three med-surg ICUs, all devoted to heart patients; this, in a 300-bed hospital. Focusing on such high acuity patients accomplishes several goals. First, the hospital can support several dedicated heart surgery teams, each of which sees large numbers of patients annually. Second, the hospitals are able to purchase ICU heart supplies in bulk. Third, in making heart care its top priority, the hospital is willing to devote considerable resources to the success of the heart program, including adding new ICU beds, introducing protocols to improve efficiency, and constantly seeking new heart business. Fourth, by having such a high patient acuity, the cardiac ICUs can attract the most qualified critical care nurses in the city. Fifth, a large heart ICU caseload allows for more staggered nurse staffing, with a few

nurses arriving at 7 a.m. and more brought on at 11 a.m. when morning surgery is over. Smaller caseloads at other institutions will not support as much flexible staffing. Nor are nurses as experienced in caring for bypass patients post-operatively. And sixth, with so many heart cases per year, management can standardize treatment patterns and supplies because the return is worth the investment. By contrast, hospitals that devote only a small portion of ICU care to heart patients often lack the ability to expand bypass volumes and face resistance from many other specialists demanding ICU support.

11.6 Routine Nurse Staffing

All four hospitals in the original demonstration felt they had made significant progress in reducing nurse staffing in caring for heart patients. The general decline in inpatient activity hospital-wide has reduced the demand for nurses. This is true even for coronary disease patients requiring complex, invasive, bypass surgery.

11.6.1 Critical Care Pathways

Probably the most significant, and obvious, change in routine nursing support for bypass patients has come about through the development of critical care pathways. Faced with incentives from the demonstration (and managed care more generally), demonstration hospitals have implemented detailed protocols to manage bypass patients during their stay. Exhibit 11-2 gives one example of a critical path protocol. Specifying the decisions to be made by a given point in a patient's stay avoids bottlenecks and untracked cases that become expensive outliers. Clinical nurse specialists monitor each bypass patient daily in the cath lab, the OR, in the ICU, and finally, in routine nursing. Not only do they monitor patient progress and encourage quicker discharging to other units within the hospital, they also study long-stay patients to identify factors that cause excessive stays.

The pathways are divided into discrete periods of a patient's hospitalization: admission to cath, cath to surgery, ICU, and routine nursing. Consider, first, the time from admission to catheterization and then to surgery for DRG 106 patients having their angiography done in the demonstration hospital. The hand-off between the cardiologist and the surgeon often is a weak link in shortening DRG 106 stays. Cardiologists often spend considerable time deciding what kind of therapy is most appropriate, drugs, angioplasty, or bypass. The pathways encourage a quicker decision to perform angioplasty or go directly to bypass surgery. For instance, one demonstration hospital is set up to operate on Friday night or on the weekend, if necessary in

EXHIBIT 11-2
CRITICAL PATH
CORONARY ARTERY BYPASS
(DRG 106 & 107)

	Same Day Admit or Preop Hospital Day	Operative Day Admit to PACU	Postop Day #1 PACU → Intermediate	Postop Day #1 Intermediate →	Postop Day 2 Intermediate /2000B	Postop Day 3 2000B	Postop Day #4	Postop Day #5
Activity	Adlib	Bedrest	OOB in am* to chair Walk in pm	→	Eval for Tx to 2000B Up in chair x3 and ambulate bid	Progress to independent ambulation	← Evaluate for D/C	
Assessment	Preop Weight _____	Pain control/intervention	Daily weights qd until D/C	→	Assess bowel status Evaluate fluid balance/weight & diuretics			
Consults/Referrals	H & P by PA in office/hospital room							
Treatments (Meds, diet, lines, etc.)		Ventilator support, cardiac monitoring, hemodynamic monitoring, vasoactive meds prn Consider extubation	Extubate D/C Swan D/C Removac D/C NG one PIV/Heplock Continue cardiac monitoring Advance diet as tolerated Remove leg drsg, clean with H2O, and apply stockings	Wean O2 to sat >90 (pulse ox)	Delina (remove Foley, Swan & A-line) Evaluate for CT D/C Maintain Heplock until tele D/C RVS hose	Change CT dressing to Band-aid 24 hr after removal Tele: eval for D/C	TPW's removed	
DC Planning	Assess home situation and resources				Consult Home Health Care Coordinator or Social Services prn			
Patient Education	Preop teaching by CNS in office/hospital room	Family support			Begin ongoing discharge instruction c patient & family per 2000 Staff & CNS			Per Cardiac CNS: Med list Scripts Appts Rehab sign-up Suture appt
Diagnosis	CXR within 1 month EKG within 1 week Lab studies-- CBC, chem profile, PTT, PT TCT, Plt, L-B-C, UA, T&Cx2	Lab studies--CBC, qluc, ionized Ca (on admit and daily) Mgt, EKG, Portable CXR (STAT), ABG, K+ (q6*)	EKG, CXR Lab studies-- CBC, L-B-C, qlucose Transfer to monitored bed (Intermediate)	Lab studies-- K+ qd* prn Pulse Ox daily until O2 D/C	CXP--day following CT removal Lab studies-- CBC, L-B-C	(Final Labs-- CBC, L-B-C) EKG (final)		
Diet		NPO	Advance as tolerated to &fat *Chol	→	Eval FLUID GOAL			
Other			TOTAL FLUID GOAL 2000 cc po/IV	→				

*depending on time of transfer

order to minimize the delay between angiography and surgery. The other demonstration hospitals are not as aggressive in taking patients "at the last minute".

For DRG 107 patients, three of the four demonstration hospitals have aggressively implemented same-day surgery protocols, thereby saving a day of routine nursing. All patients within a geographic radius (usually 50-100 miles) are targeted candidates for same-day surgery. Testing and patient clinical interviews are conducted the day before in the physician's office adjoining with the hospital. Patients arrive at 5:30 a.m. the day of surgery and are prepared for the operation, having stayed at home or in a local hotel. To give some idea of the scope of the program, one hospital did same-day bypasses on 63 patients in 1993, and on 91 patients partway through 1994.

The movement towards same-day surgery admissions, it should be noted, is not solely due to the demonstration. Blue Cross in Michigan, for example, was denying extra days at St. Joseph's Mercy Hospital in Ann Arbor. In response, the hospital adopted a same-day surgery policy hospital-wide. Everyone agreed, however, that the incentives to shorten stays under the demonstration made surgeons and anesthesiologists more cooperative when it came to extending the concept to bypass patients.

11.6.2 Other Factors in Shortening Stays

Other key factors in shortening stays and saving on nursing inputs noted by participants included (a) changing patient mindsets about how long they should be in the hospital, (b) avoiding over-monitoring, (c) ambulating as soon as possible, and (d) picking up arrhythmias early and changing drug regimens. No patient likes to feel she is being rushed out of the hospital--especially if they feel they have paid for a longer stay through their health premiums. The challenge of nurse specialists is to change patient, family, and even physician expectations that a bypass stay is no longer routinely 15 days or more. Hospital staff have done this by updating the information pamphlet given bypass patients to give a more accurate expected stay--often 8 days without complications. Some hospitals have produced videos to help patients understand their discharge rehabilitation regimen and the course of convalescence. Patients must recognize that some pain after discharge is normal. They must also be able to distinguish benign pain from true warning signs. All hospitals use home health nurses to follow up particularly serious cases that need home support. Respondents said it was equally as important to change surgeons' mindsets as well. The demonstration was particularly helpful, some nurses said, in getting surgeons to accept the new protocols and save on nurse resources. Although both patients and physicians are inconvenienced by same-day

surgical admissions and shorter post-operative stays, both are seeing the benefits of as short a stay as possible.

Over-monitoring, especially resulting from taking blood gases too often or keeping patients on 24-hour telemetry on routine floors, produces many false positives that prolong stays. One hospital has avoided using routine telemetry or all bypass patients because of the high false positive rate. On the other hand, nurses noted that arrhythmias must be identified early so that drug changes can be made. If not, they can add several unnecessary days to a patient's stay. In general, patients are weaned off vasoactives and do not continue with "drips" on the routine floors, but some will still be on antiarrythmics to control heart beat.

Ambulation is now considered key to shortening stays, and nurses in the ICU and on the floors have quantitative goals regarding extent of walking and exercising.

11.6.3 Resistance by Non-Demonstration Specialists

Nurses and managers also spoke about the continued resistance to critical pathways in other areas of the hospital, such as orthopedics. Even floor nurses sometimes resent the nurse specialists intruding on their domain. There is little doubt that paying a single combined payment has brought the surgeon, anesthesiologist, and cardiologist over to the hospital's side in accelerating patient flow through--at least in three of four hospitals. Private managed care could do the same thing, but until other specialists come under the same global incentives to conserve on scarce hospital resources, they appear unwilling to change their practice patterns.

11.7 Pharmacy

Based on interviews with hospital pharmacy directors, the demonstration has resulted in considerable cost savings. Drugs for heart patients can be divided into six categories: (1) cardioplegic solutions used during surgery; (2) anesthetics used during surgery or catheterization; (3) vasopressors used to restrict blood flow in the arteries; (4) anti-coagulants and diuretics to thin blood flow and eliminate excess fluids; (5) anti-infection drugs; and (6) medical therapy drugs. Incentives to reduce costs embedded in the single payment have encouraged surgeons, anesthesiologists, cardiologists, and other specialists to review their drug formularies and make cost-saving substitutions.

11.7.1 Cardioplegic Solutions and Plasma Expanders

Consider, first, changes in cardioplegic solutions. Hespan is a brand name cardioplegic pooled blood solution used intraoperative to expand blood plasma. It is put into the veins to retard large molecules from escaping and results in fewer blood products being used. One pharmacist reported that Hespan costs $50 per bag versus $6 per bag for a close substitute, Lactex. Over the 1992-3 period, one demonstration hospital reduced its use of Hespan from 189 units per month to just 40 units. Monthly Hespan usage was costing the hospital $6,522 in July of 1992, compared with $1,380 in December of 1993. Between 1992 and 1993, the hospital estimated it saved $47,554 in Hespan costs alone as outlays fell 62%.

It is interesting that the one hospital where physicians tended to resist drug substitutions used the less expensive albumin instead of Hespan in the operating room. This may be explained by the differing attitudes of specialists towards brand and generic drugs in the same institution. In their operating room domain, surgeons may be quite willing to use less expensive products while the opposite may be the case for, say, anesthesiologists, or for cardiologists.

11.7.2 Anesthetic Agents

Significant savings have also be achieved in anesthetic agents. The generic drug, fentanyl, is a preferred narcotic agent for open heart surgery. Many hospitals, including some of the demonstration facilities, had switched to the brand drug, Sufenta, at six times the cost of the generic drug. When one demonstration hospital began substituting the generic anesthetic in early 1993, it was spending roughly $15,000 a month on the two narcotics. By December, the monthly outlay had fallen to $1,000. The overall comparison of 1992 with 1993 showed a savings of $108,123, a 70% reduction. The pharmacy department conducted performance studies for the anesthesiologists and found that the generic, fentanyl, caused less rebleeding and had shorter ventilation times compared to the expensive brand drug. Shorter ventilation times also helped shorten ICU stays as an added savings. Another demonstration hospital reported a reduction of $107,590 by substituting the generic for the brand narcotic over the same two-year period.

Not all hospitals were equally successful in switching to the less expensive narcotic. In one academic medical center, the anesthesiologists refused to give up Sufenta, and the pharmacy department was not able to convince them of the cost effectiveness of the generic.

Another drug substitution that was mentioned was the switch from the brand drug, Versed, to Valium (now off-patent) which could save considerable money in sedating patients

undergoing cardiac catheterization. One hospital had given anesthesiologists cost and performance information on the two drugs in the hope of switching to the less expensive narcotic.

11.7.3 Vasopressors

Dopamine vasopressors stimulate contraction of the muscle tissue surrounding the arteries, thereby slowing blood flow. They are key to correcting hemodynamic imbalances caused by heart attacks, trauma, and bypass surgery. One hospital reported switching from the brand, dobutamine, to the generic, dopamine, and the pharmacy is now in the process of preparing a report on the cost savings to the hospital.

11.7.4 Anti-Coagulants and Diuretics

Anti-coagulants play a major role in the clinician's armamentarium. They thin the blood in treating venous thrombosis and embolisms as well as allowing the blood to "slip through" occluded arteries. Heparin is commonly used as an anti-coagulant. Protamine is used to counteract the thinning effects of Heparin. One hospital pharmacy reported that generic Protamine cost $3.93 per vial versus $16.15 for the brand drug. At a rate of 1,700 vials per year, the hospital saved $20,774 in 1993 alone by switching to the generic.

Diuretics also play a key role in managing heart patients. Brand name drugs such as Bumex and Lasix are used to treat edemas for congestive heart failure, for hypertension, and for renal disease as a comorbid condition. Lasix is reported to cost pennies per day versus $50 per day for Bumex. When one hospital began substituting the cheaper product for Bumex when possible, monthly costs fell from $7-8,000 to $3,500-$5,000. Annualized savings for 1993 were estimated to be $38,535, down 42% over the year before.

11.7.5 Anti-Infective Drugs

Hospitals spend large sums every year on anti-infective drugs. One hospital reported convincing surgeons to remove the expensive brand drug, Vancomycin, from the protocol and using the generic substitute, Cefazolin, exclusively. Cost savings were not available at the time of the interview.

11.7.6 Medical Therapy Drugs

Besides the drugs complementary to the care of bypass patients, cardiologists have many new drugs for the nonsurgical treatment of coronary stenosis. Probably the most well-known is streptokinase and its brand substitute, TPA. These drugs improve ventricular function in congestive heart patients by decreasing clotting, and in managing patients experiencing heart attacks. They help clear occluded arteriovenous cannulae without invasive, risky, surgery. Although TPA is eight times more expensive than the generic drug, hospitals were continuing to use the brand as a result of recent clinical studies showing greater efficacy.

11.7.7 The Role of Surgeons in Drug Substitution

Pharmacists that were interviewed emphasized that changing physician attitudes were critical in substituting more cost effective generic drugs for brand names. In two of the demonstration hospitals, the pharmacy has had considerable success in getting surgeons, anesthesiologists, and cardiologists to try less costly drugs. This change in attitude, pharmacists believed, is directly tied to the incentives to control hospital costs that physicians face under a single bundled payment. With the explosion in pharmacy budgets in the last ten years, hospital managers have pressured pharmacists to reduce costs wherever they can. But they do not prescribe inpatient drugs. Physicians do. And managers have not been willing or able to effect much change in drug mix. Under the demonstration, surgeons hospitals are taking a closer look at cardioplegic solutions, anti-coagulants, vasopressors, and anesthetics and how much they cost. They are working with their colleagues and the formulary substitution committees to try less costly drugs. Based on comparative data and references from colleagues in other institutions. Having surgeons lead the discussion on drug substitution appears far more effective than pharmacists, who are often viewed as aligned with hospital "cost cutters" unconcerned with patient outcomes. Under the demonstration, physicians are now asking pharmacists to attend clinical meetings and to conduct performance and cost studies to see if a switch is possible. They are also challenged by what colleagues in other institutions are doing.

In spite of the incentives, not all pharmacy departments in the demonstration hospitals have been equally successful. Anesthesiologists in one academic medical center refused to substitute fentanyl for Sufenta. The surgical pump teams in two institutions were unwilling to standardize their cardioplegic solutions from 8 to 2 as recommended. Resistance rates to the generic anti-infection drug rose, and Vancomycin was readded to the formulary. Nurses in the same hospital balked at substituting syringe pumps in pre-op for bags. Cardiologists continue

to use many different kinds of ace inhibitors, frustrating pharmacist attempts at standardization. Based on subjective impressions, much seems to depend upon the aggressiveness of the lead surgeons. Where they are not willing to discuss changes with colleagues, the incentives under the demonstration are often not strong enough to have other specialists act on their own. This is especially true for anesthesiologists, who stand to gain little from any substitutions.

11.7.8 The Role of Pharmacists

How costly drugs are monitored and managed within hospitals has changed over the demonstration. Pharmacists will target, say, the top 20 most costly drugs in the hospital and review them for possible substitutions. If physicians ask for a special study, they will do it. Several requests have been made under the demonstration, including albumin, Vancomycin, contrast media, and antibiotics.

The pharmacy staff have also played a role in changing standing orders for drugs. Physicians in the demonstration have been cooperative in general in reducing routine drug usage and substituting less costly drugs, such as oral ulcer drugs at $3 per day versus H2-antagonists at $10 per day.

Another way pharmacies have saved money is through carrying smaller inventories. A typical hospital's inventory turns over 12 times a year. In one demonstration hospital, the turnover is 29-fold due to daily drug deliveries from wholesalers. The key, pharmacists report, is educating nurses to be comfortable with slightly longer waits to refill supplies. A second hospital uses Owens and Miner (a wholesaler) to guarantee stocks with only a 6% mark-up on wholesale prices. Over $700,000 is saved by not holding 4-month inventories.

To speed up drug availability on the floors, some pharmacies have put local dispensaries in the operating room area, the ICU, and in the Catheter Lab. This avoids wastage as well.

Practically all institutions have joined a purchasing group to buy drugs, thereby maximizing their market power. For example, by joining 48 other academic medical centers, one state hospital in the demonstration has access to over 7,000 products without going out for competitive bidding. Under the old system, the hospital had to seek competitive bids on over 700 product lines including several that involved less than $5,000 annually. With the joint purchasing arrangement, the hospital gets a two-year lock-in on prices along with a bundled discount on the supplier's entire product line. The one drawback to this arrangement is that the hospital cannot secure best prices from particular suppliers of specialized drugs and

devices, such as catheters. Thus, some potential savings to cardiac patients are foregone in order to save on drug purchases hospital-wide.

11.8 Operating Room

11.8.1 Volume Growth and Efficiency

Improving efficiency in the operating room is a special challenge. All hospitals joined the demonstration with the expectation that bypass volumes would increase, and with growth would come more intensive, efficient, use of the inmost expensive service. To date under the demonstration, the results regarding volumes have been mixed. In the two non-academic centers, bypass volumes have increased. In the two academic centers, volumes have been flat. In the two facilities with significant growth, one was performing 1,300 cardiovascular surgeries in 1993 in three dedicated operating rooms (out of 16) while the other facility was performing 1,920 surgeries (70% bypasses) in 4 dedicated rooms (out of 14). Of the four facilities, only the last was fully utilizing available operating room time. Even in the other high-volume institution, the cardiovascular suites were running 66% occupancy (with an 80% target).

One reason for slower-than-expected bypass growth is the explosive growth in angioplasty, which has siphoned off many 1, 2, and 3-vessel cases. Besides the growth of angioplasty, one thoracic surgeon also noted that there was "no more general surgery in the hospital due to the diffusion of endoscopy." While a slight exaggeration, endoscopic surgery does explain why surgical rooms are not as fully occupied as they used to be. More surgery is being done outside the hospital or in a much shorter time in the operating room. Also mentioned as a factor in curtailing volume in one hospital was the new chest pain center that treated patients with drugs, first, before referring to surgery as a last resort.

Some practitioners made interesting comments on the reasons behind the inverse relationship between bypass volume and mortality rates found in the literature. Performing many cases gives the surgeon and anesthesiologist valuable experience in dealing with unusual cases. Weaning patients from the pump is critical. An experienced perfusionist can evaluate pump performance and modulate flows to speed up the process. Experienced physicians also are more sensitive to adverse changes in blood flows that are critical to operative success. Moreover, in a high-volume hospital, nurses and assistants are more adept at harvesting veins and avoiding damage by squeezing them too tightly. And the nurses in general are quicker to react to adverse events. There is a great deal of random response of patients to the trauma associated with bypass surgery. A team that has seen the gamut of responses are (a) quicker to respond to a problem in the correct manner, and (b) more likely to avoid adverse events in the first instance.

11.8.2 Bypass Surgery Times

Length of bypass surgery is important, not only to costs, but also to outcomes. Every minute on the pump or under anesthesia heightens risk. Times have fallen in the operating room. One operating room director reported that 3-4-vessel bypasses that took 4 hours in 1992, now take 3 hours. Redo's of patients with previous bypasses that used to take 8 1/2 hours now take 5 hours. Overall pump times may be longer in some facilities, however, because bypass patients are sicker with more vessels to bypass.

The key to short operating room times seems to be dedicated cardiac teams. Everyone in the room is doing specified activities concurrently: opening the chest, harvesting the veins, opening supplies and laying out instruments, closing up, packing supplies. Maximum efficiency using dedicated heart teams can only be achieved with high volumes. Otherwise, teams are broken up, some members performing other types of surgeries, some assigned to nonsurgical activities. Consistently high volumes allow teams to stay together for a full day, day after day. Failure to achieve volume growth may have hindered the two academic institutions in developing as many dedicated teams as the other two demonstration hospitals, with some foregone efficiency gains.

11.8.3 Operating Room Scheduling and Teams

Rapidity of room turnaround is the final crucial element in maximizing expensive operating room time. Two hospitals prided themselves on reducing turnaround times: one from 40 to 30 minutes; a second, from 30 to 23 minutes. Again, turnaround was not as critical in two hospitals with constant volumes.

Who is in the operating room during the surgery? Teams vary slightly, but the standard group includes the thoracic surgeon, a physician assistant, the anesthesiologist, a perfusionist, and a scrub and a circulating nurse. Additional members may include a surgical or anesthesiology resident. Most hospitals did not use CRNAs for bypass surgery although the highest volume facility did assign half (13) of their CRNA staff to bypass patients under anesthesiologist supervision. This institution, because of its dedication to heart surgery, had all 16 of its supervising anesthesiologists trained in bypass surgery, assuring maximum physician flexibility for emergency bypass cases.

PAs are common in nonteaching facilities while residents assist the head surgeon in academic medical centers. One academic center would not let the surgeon use physician assistants, arguing that residents needed the training. Problems arose, however, when residents were unavailable.

Three of the four hospitals ran standard weekday OR schedules, starting the surgery at 7:30 a.m. and finishing in mid-afternoon. The high-volume hospital was unusual in adding a fourth room beginning at 8:30 a.m. to stagger patients. This hospital also ran a regular Saturday open heart schedule with one team from 6:30 a.m. to 6:30 p.m. The reason for this, it was explained, was the high number of DRG 107 referrals that were made by outlying hospitals on Friday in order to avoid expensive weekend stays. In order to "capture" these referrals, the demonstration hospital made special accommodations for Friday night, followed Saturday surgery to minimize overall stays. By contrast, one academic center reported performing only 1-2 open heart surgeries per month on a weekend with no Saturday surgery.

When angioplasty was first performed, all hospitals kept an operating room and bypass team on stand-by in care of failures requiring immediate revascularization. This was obviously very costly. As catheterization techniques have improved, and with the ability to use stents to prevent excess bleeding, PTCA "crashes" have become rare. Consequently, hospitals no longer have dedicated rooms and surgical teams waiting. In emergencies, the next available team will take the failed angioplasty. Staggering one of the rooms also reduces the waiting time in case of an emergency.

11.8.4 Purchasing Supplies and Instruments

Another way hospitals have been saving money in the operating room is by better managing and purchasing supplies. In one hospital, the largest surgical group meets weekly to discuss standardization of products. Among other things, this led to the standardization of the cannulas that route blood to and from the pump. After physicians agreed upon the product list, OR nursing staff give new surgeons the list of products that are used in bypass surgery. Knowing that their experienced peers designed the list minimizes requests for unusual supplies and instruments. In another hospital, all surgeons must bring all new equipment (e.g., valves, elbows) before a standards committee before bringing them into the operating room.

Operating room managers also report returning to reusable items such as lab coats, light handles, and gowns in order to reduce costs. Nurses are also saving by using supply packs that are opened only when necessary. As a result, one hospital manager reported going from $300,000 over budget in the operating room to $140,000 under budget through changes engendered, at least in part, by the demonstration's incentives for more efficient use of the service.

At another hospital, the head thoracic surgeon is the only one allowed to deal directly with outside vendors. He supports the hospital in standardizing valves and other supplies and

discourages vendors from playing off one surgeon against another. Hospital staff, alone, are unable to limit access of vendors to surgeons and anesthesiologists, partly because of their lack of technical knowledge, partly because of a lack of control over physicians. Aligning financial incentives encourages physicians to police themselves.

11.9 Anesthesia

Three important changes have taken place in the way anesthesia is delivered that has reduced costs. One involves same day admissions in DRG 107; a second, the therapeutic substitution of low-cost generics for brand narcotics in the operating room; and the third, and most important cost saver, has been the trend toward earlier extubation after surgery in the ICU.

Because open heart surgery is so traumatic and usually requires several hours to complete, the anesthetics must be planned well in advance. Same-day surgery shortens the time to develop an anesthesia plan, and anesthesiologists in general were resistant to the idea until recently. But over the last ten years, the growth in same-day surgery has been remarkable. Every year, more challenging procedures are being done on a same-day basis (or even as day surgery). Only in the last 3 years, however, has the concept been extended in any significant way to open heart surgery. Demonstration hospitals have been in the forefront of this change. The implications for anesthesia are significant. Now, patients visit the anesthesiologist's office at the hospital the day before surgery and give a medical history and other pertinent information to the nurse specialist. The patient is also instructed as to eating and other important behaviors the night before surgery. Anesthesiologists have had to make special arrangements for these interviews, unlike formerly when they visited the patient on hospital rounds the day before surgery. Having already established the protocols on other same-day surgery made the "jump" to same-day open heart surgery feasible within the short time-frame of the demonstration.

In Section 11.7, the substitution of fentanyl for Sufenta was discussed and need not be repeated here. Significant savings on brand narcotics have been realized in a couple of the demonstration hospitals, with definite spillover savings on non-demonstration patients because the drug switch was made for all open heart patients (unless patient condition calls for another drug which occasionally happens). Savings on narcotics, however, have been uneven across participants. Anesthesiologists will not change anesthetics unless pushed by surgeons. Hospital managers or pharmacists are usually unsuccessful in effecting a change in narcotics. Thus, much depends upon the willingness of surgeons under the demonstration to push for

therapeutic changes. Having comparative data from other institutions on the use of generics can be very helpful.

Early extubation has also been discussed in Section 11.5 under changes in the ICU. In all four institutions, anesthesiologists were aggressively taking patients off ventilators soon after surgery. Staff in one hospital reported that now 60-70% of patients are extubated on the first ICU day versus only 20% before the demonstration started. Patients used to remain on ventilators overnight. Accelerated extubation is cited as the primary reason ICU days have fallen by nearly 50% under the demonstration.

Although it was difficult to say what effect the demonstration per se had on the role of physicians in managing ICU patients after surgery, it appears that anesthesiologists may be taking a more active role than previously. Early extubation involves careful management of respiratory functions and is properly the domain of the anesthesiologist rather than the cardiologist or other attending physician. From other comments, discussed more fully in Chapter 13, there seems to be a trend towards more oversight in the ICU by the surgeon and anesthesiologist and less by consulting physicians.

11.10 Catheter Lab

Activities carried out in the catheter lab directly and indirectly affect the mix of patients undergoing bypass surgery and the overall costs of demonstration patients. All DRG 106 patients had their angiography performed at the demonstration hospital. The proportion of patients in DRG 106 varies considerably across the hospitals. In Atlanta, St. Joseph's Hospital performed the angiogram on only 25% of its bypass patients compared with 61% at Ohio State University Hospital. Performing the angiogram adds over $1,000 to DRG costs, not counting the 3-4 extra days in the hospital versus DRG 107 patients. How efficient hospitals are in conducting these exams directly affects DRG 106 costs.

Probably more important is the indirect effect the catheter lab has on the number and mix of patients going on to bypass surgery. With the introduction of angioplasty, fewer patients are immediate candidates for bypass. The more aggressive cardiologists are in performing angioplasties, the fewer patients will be seen by the thoracic surgeon. Furthermore, as angioplasty techniques and technologies improve, only those patients with the most extensive coronary disease, or with left main disease, remain candidates for bypass surgery.

A wide range of activities take place in the lab, but they can be grouped into five domains: (1) electrophysiology (EP), including pacemaker insertion; (2) echocardiography; (3) noninvasive cardiology, including angiography; (4) invasive cardiology, including angioplasty;

and (5) cardiac rehabilitation, including stress and Holter studies. Electrophysiology and echocardiology have been high-growth centers for most hospitals. EP studies were increasing 10% annually in one hospital while echocardiography was growing 13% annually over the last several years. Angioplasty, in general, has also been a high-growth area for most of the demonstration hospitals. In one hospital, the number of angioplasty procedures increased from 412 in 1990 to 618 in 1993. In another hospital, the lab was performing 22 procedures of all types in 1990 and was closing at 11 a.m. By early 1994, the lab was averaging 33 cases and the lab was open until 7 p.m. Much of this growth was due to the explosion in angioplasty.

Not all demonstration hospitals were enjoying volume growth. One hospital had seen angioplasty volumes decline from 1,400 in 1992 to 1,150 in 1994. The reason given for the decline was the opening of competitive labs in the market area.

The growth in angioplasties in three of four hospitals implies a more severe case mix undergoing bypass surgery. Other invasive cardiology procedures besides balloon angioplasty, including atherectomy (balloon with smaller cutters), rotoblades (high speed diamond drill), and lasers, also reduce the proportion of admitted patients going on to bypass surgery. (This ignores the potentially positive effects of a growing catheter lab on attracting more coronary patients in general.) One academic medical center estimated that only 25% of patients with triple-vessel disease were recommended for bypass while 60% underwent PTCA and the rest had drug therapy. In another non-academic institution, of patients undergoing angioplasty, about 10% had either left-main or triple-vessel disease. These statistics indicate a strong shift away from one- and two-vessel disease going to bypass, and even healthier patients with triple-vessel disease are having angioplasty as the first alternative to drug therapy.

Although the cost of angioplasty is not directly relevant to the evaluation of bypass surgery, it is interesting to note the high costs of this alternative. The catheters themselves cost only $15 each, but the balloon catheters retail at $700. Occasionally a stent is used in addition to secure the artery which costs another $680. The national average is 1.75 balloons per lesion, resulting in over $1,000 in balloon costs alone. In addition, expensive anti-coagulants are required. One hospital cath lab director estimated that he spent $1.9 million annually just on medical supplies and devices, even after a 25% discount.

Rapidly rising costs in the cath lab has forced managers to become more efficient. One hospital has set up a 14-bed unit next to the lab to handle pre- and post-procedure activities efficiently. The primary reason for taking this step was to minimize downtime in expensive lab rooms.

Another efficiency-enhancing step was contracting with outside evaluators to provide comparative data and suggestions for improving lab procedures. According to the director,

cardiologists "were amazed at what other physicians and labs were doing" in terms of number of balloons, the overall costs of procedures and drugs, room turnaround time, etc. Key to saving cath lab costs is maximizing utilization. Downtime is very costly in terms of staff salaries and underutilized equipment. For hospitals with a single cardiologist group, scheduling is simplified as one physician uses a room for the entire day. This is more likely in an academic medical center than a community hospital. In Atlanta, by contrast, St. Joseph's has 5 busy cath labs and 60 cardiologists in private practice. In this instance, extraordinary steps have been taken to minimize downtime. Teams have been formed with goals in terms of turning rooms around for the next patient. Average turnaround times fell from 55 to 25 minutes. Furthermore, average waiting times for cardiologists once rooms were ready were posted in the physicians' locker room. Almost immediately, waiting times for cardiologists fell from 35 to 15 minutes. Turn-around times will be systematically related to the "ad hoc" PTCA philosophy of the center. It may be more cost effective to follow an angiogram immediately with angioplasty during the same lab visit. This naturally plays havoc with the schedule but saves time and money by eliminating a return to the lab later in the admission or readmission.

Standardization of supplies has also been at the top of the lab's agenda for cost containment. In one hospital, the number of different balloon vendors was reduced from 7 to 2. This allowed the hospital to negotiate large reductions in prices.

Many of the cost savings in scheduling and purchasing depend upon cardiologists agreeing on key issues. In academic medical centers, standardization is easier because there is a single practice for each specialty. Cardiologists also tend to be assigned rooms for the day rather than by patient. Patients are then assigned to rooms rather than physicians, thereby avoiding problems waiting for the next physician.

Some hospitals have made staffing changes to lower costs. Usually, each angioplasty requires a circulating nurse to monitor the patient's vital signs, a scrub nurse to assist the cardiologist, and a technician to control and monitor the equipment. Teaching hospitals may have up to five persons in the room, creating crowding problems. Another staffing change has been to substitute physiologists for one of the nurses. Much of the work is hard and physical in terms of transporting and shifting patients for viewing and manipulation of the catheter. Physiologists certified in pharmacologic testing can replace one nurse at half the cost. They also can be more attentive than a nurse who is trained for other purposes.

Assignments have also changed. Nurses in one hospital were now pulling the catheter sheaths in the post-operative room adjacent to the lab and sending patients directly to routine nursing. In the past, patients had been sent to the ICU where sheaths were removed at the cost of a day's ICU stay. Whether sheaths can be pulled in the post-recovery room depends on the

success in PTCA dilatation. Long, difficult cases will generally require keeping the sheath in overnight to check the lesion the next day and to monitor anticoagulants.

A final area of cost savings in the cath lab concerns the use of contrast agents. In performing angiograms, either less expensive ionic or much more expensive non-ionic agents are used. Non-ionic agents are believed to be superior in avoiding renal failure and cardiac arrest, but the likelihood of adverse events are very rare in most cases. During the demonstration, one hospital switched from using non-ionic agents all of the time to just 50% of the time after outside evaluators showed cardiologists the equivalence of the two agents in terms of outcomes, coupled with the fact that their case mix was, in fact, not more serious than other institutions. A second demonstration hospital uses non-ionic agents only 30% of the time at a savings of $500,000 a year. Non-ionic agents are still used for patients with high creatanine levels that are at risk for renal failure.

12.0 CASE STUDY FINDINGS: HOSPITAL COMPETITION AND MARKETING

12.1 Introduction

A principal reason most hospitals gave for participating in the demonstration was to increase bypass surgery volumes. How successful they were in achieving this goal depends upon how they promoted the program. A vigorous, intelligent, marketing program, however, does not guarantee success. One major obstacle to greater volumes may be internal conflicts and constraints within the demonstration hospitals, themselves. Some of these have been touched upon in Chapters 10 and 11. Others will be mentioned in later chapters dealing with the achievement of participant goals. But even if hospitals faced no internal problems, one cannot ignore the external competitive market. It is reasonable to expect competitors to respond, sometimes vigorously, to a local hospital being named a Medicare Bypass Center. Their efforts may thwart promotional attempts to gain market share by demonstration hospitals, leaving the market *status quo ante*.

On-site interviews were conducted in each of the demonstration hospitals to determine their marketing strategies and promotional efforts. As will be described more fully below, marketing was directed at three groups: directly to potential patients; indirectly to referring physicians; and indirectly to managed care plans. How successful were the participants in marketing to the three groups? Did the sites vary in their emphasis on direct versus indirect marketing? How was their marketing molded by their academic orientation and how much by local market structure? Can any generalizations be made from just four case studies about the success of the program in shifting market shares elsewhere in the country? These are the kinds of questions addressed in this chapter.

Besides interviews in participating hospitals, interviews were also conducted among competitors. Perceptions of the market will vary from hospital to hospital and from physician to physician. Secondary data on volumes, reported in Chapter 4, provide scant evidence of competitor responses to the program. Personal interviews with competitors supplied missing subjective information on how others in the community viewed the selection of a Medicare Bypass Center, what impacts it had on referral patterns, how competitors responded, and any problems competitors saw with the demonstration. Like those interviewed in participating hospitals, outside competitors had their biases, and it was impossible with quantitative data to evaluate some of the assertions made by either side. Nevertheless, documenting perceptions of the competitive process and how demonstration hospitals have behaved is key to producing a balanced evaluation.

12.2 Organization of Hospital and Competitor Interviews

To document the ways in which demonstration hospitals promoted the program, several interviews were conducted with hospital marketing staffs. These included the hospital marketing director, the marketing staff, the person responsible for private managed care contracting, and physicians involved in the promotional efforts or building primary care networks.

Questionnaires covered three broad areas: (1) marketing strategies; (2) managed care contracting; and (3) the responses of competitors. For examples of the interview protocols, see Appendix 10.

Interviews with other local competitors were also conducted in order to gain a more balanced and complete picture of the nature of bypass competition and the impact of marketing by demonstration hospitals on competitors. Any problems or concerns with the demonstration were also pursued in the interviews. The original evaluation design called for at least one set of competitor interviews in each site. Difficulties gaining cooperation limited the interviews to just two competitors in two sites. One set of responses came from another academic medical center; another from a large private hospital. From just two observations, it is impossible to generalize on matters concerning the nature of competitor responses to the demonstration. These interviews did prove valuable, nonetheless. First, they give a broader perspective on the organizational problems facing any academic medical center in aggressively pursuing global contacts of the kind envisioned in this demonstration. Second, some of the responses shed light on why the volume gains were or were not as large as demonstration hospitals expected. Third, competitors raised a few critical points about the contracting process and the possible behavior of selected hospitals that, if true, raise serious concerns about quality of care, and, if false, indicate the degree of misperception in the community that could undermine future contracting efforts.

12.3 Global Package Competition in Local Markets

All respondents felt that competition among hospitals and physicians had increased significantly in the last five years. This was the result of several factors. First, the growth of managed care had been dramatic everywhere, with the possible exception of Boston where it was already well established. Atlanta, Columbus, and Ann Arbor could all be considered Stage I markets where HMO penetration is just taking off. Hospitals in these cities have not traditionally had to compete for private patients--at least not through third-party plans. In Atlanta and Columbus, HMOs have begun entering as they work their way down from the

larger cities. In Ann Arbor, respondents felt that the United Auto Workers had discouraged the penetration of HMOs for many years due to their very rich, first-dollar, coverage with complete freedom of choice. Now that hospital costs have driven premiums to unaffordable levels, HMOs are gaining a foothold and changing patient perceptions about the need for managed care.

A second factor affecting competition was the diffusion of catheter labs. Managers and physicians both cited the growth in the number of labs as detrimental to their bypass volumes. Noninvasive and invasive labs both affect volumes, particularly the latter. As competitors begin performing angioplasties as a substitute for bypass surgery, referral patterns change dramatically, and never in favor of established labs such as those in the demonstration hospitals. Hospitals with existing labs have opened them to outside cardiologists as well. After the Deaconess Hospital and Lahey Clinic both opened the labs to outsiders, their bypass volumes grew rapidly, taking away market share from University Hospital. Academic medical centers, including Ohio State University Hospital, have resisted opening their labs to cardiologists not on the medical school faculty. University Hospital did open its lab one day a week and has seen greater volumes as a result.

And third, all four demonstration hospitals face one or more major competitors. In Boston, University Hospital faces 6-7 nearby hospitals that perform open heart surgery, including many academic medical centers with excellent reputations. St. Joseph's Mercy Hospital in Ann Arbor competes directly with the University of Michigan just a couple of miles away as does St. Joseph's in Atlanta with Emory Medical Center. Ohio State University is unique among the four in being the single academic medical center in a mid-sized city. It competes primarily against Riverside Hospital, which presents it with the same problems that the two St. Joseph's Hospitals present Emory University and the University of Michigan; namely, a very aggressive, large, low-cost, community alternative to a teaching-research environment. The competitive advantages of large, nonacademic hospitals are enhanced in areas with growing managed care plans looking for packaged prices. How these competitors maximize their market position is the topic of the rest of this chapter.

12.4 Marketing Strategies

Hospitals employ three distinct types of advertising: (1) direct advertising to patients in the media; (2) indirect advertising to referring physicians; and (3) indirect advertising/negotiating with managed care plans. Patients rarely make the decision of which hospital to choose for bypass surgery. Out of ignorance regarding quality, they rely mostly on

referring physicians. Nor do they usually consider price, given widespread insurance coverage, especially among the elderly.

As a result, the demonstration hospitals have emphasized quality in their direct media advertising. As with Ohio State University and both St. Joseph's Hospitals, this usually takes the form of institutional advertising, emphasizing the quality of care in the across all services, not just thoracic surgery. Ohio State University, in fact, did little direct advertising at all the first year. Surgeons felt that much of the market had already slipped away.

Academic medical centers are invariably slower at initiating direct media advertising to patients. The deans of medical schools often resist advertising, choosing, instead, to invoke a "they will come" philosophy. Large, prestigious medical schools have seen themselves as dominating the market for bypass surgery for such a long time, and their leaders are reluctant to admit that open heart surgery is no longer their exclusive domain. Now that referring physicians and managed care plans have several good choices in town, simply building a heart program of high reputation does not ensure high volumes. As managed care comes to direct patients more, deans are changing their perceptions of the market.

Non-academic hospitals such as St. Joseph's in Atlanta face the opposite problem of a lack of national recognition in spite of performing many more bypasses per year than Emory Hospital nearby. The same is true for St. Joseph's Mercy Hospital in Ann Arbor versus the University of Michigan. The Atlanta facility wisely emphasized quality in its media advertising. It also focused on national conferences and managed care plans to convince physicians and insurers that their care was as good as that offered by the local academic medical center. Without doubt, the imprimatur of being selected a Medicare Heart Bypass Center strengthened their argument considerably.

No hospital spent any time advertising low prices. Patients don't respond to prices, nor do referring physicians, for the most part. Managed care plans do, but they don't contract with hospitals through television or the newspapers. Institutional quality advertising assures patients that their referring physician or managed care plan has made the right choice in sending them to the non-academic demonstration hospital.

Interestingly, three of the four hospitals did little to promote their heart bypass program separately from their general institutional advertising. One argument given was that the hospital did not want to alienate referring physicians through direct advertising. They felt it might appear that the hospital was "appealing directly to the patient in making the referral decision". Another demonstration hospital went so far as to avoid blood pressure screening in malls and on campus so as not to appear to compete with local cardiologists whom they relied on for referrals. It was somewhat contradictory, then, to see the same hospital open up a Chest Pain Center that competed directly with office-based physicians. The argument for this was

that it could avoid unnecessary admissions. Staff also felt the hospital was distant enough not to disrupt most practice patterns in town.

One of the odder reasons for not marketing more actively to patients was the belief that the hospital was losing considerable money under the demonstration. Some managers felt they shouldn't be "marketing a loser". This shows a lack of understanding of short versus long-run profits. None of the hospitals were losing money in the short run; on average, demonstration patients in each site were more than paying their direct costs, as shown in Chapter 6. That is, a successful marketing program that brought in new patients would more than cover the direct costs of care of those patients. Indeed, one of the reasons this hospital gave for participating was too increase volumes and cover more of the high fixed costs of bypass surgery, as well as rebuild their reputation. But there will be other hospitals that resist giving large discounts in the belief they will lose money. The program will be a failure only if they fail to increase volumes, which will become a self-fulfilling prophecy if they fail to vigorously market it.

One surgeon who was interviewed probably summed up the dilatory direct marketing strategy best by observing that we are witnessing "the end of direct patient marketing". The reason: managed care plans.

Marketing to referring physicians and to managed care plans are the key strategies. Most demonstration hospitals have worked hard building a physician referral network. Half to two-thirds of all bypass patients in the demonstration fell into DRG 107, which meant they had their angiograms done elsewhere and then were referred. Some hospitals were buying up primary care practices, but building networks was problematic for the academic medical centers. First, the question of admission privileges limited outside interest in joining the network. Second, university inertia discouraged networking. Again, "they will come" permeated the marketing philosophy. And third, the mission of teaching and research conflicted with the demonstration goal of greatly increasing bypass volumes and emphasizing clinical care.

At bottom, all hospitals are engaged in a marketing balancing act. They want more patients, but if they do too much direct marketing, or set up pain centers, or conduct screening programs, they might alienate referring physicians. If they concentrate on their referral networks, exclusively, managed care plans may render them obsolete overnight. While they must be price-sensitive in negotiating with plans, they need to encourage employees to sign up for the plans they belong to. If hospitals start their own HMOs, and St. Joseph's Mercy Hospital in Ann Arbor has a fairly large one called Care Choices, they risk alienating referring physicians not in their plan. Until all patients are in HMOs, hospitals will not be able to have a

uniform, efficient marketing plan, and the efforts of their marketing staffs will work at cross purposes.

While it might seem that direct advertising is in decline, nothing is further from the truth in the demonstration hospitals. (University Hospital in Boston is an anomaly in doing little media advertising.) Both Ohio State University and St. Joseph's Mercy significantly increased their marketing budgets just prior to the demonstration. The former did so in response to focus groups that promoting the hospital's "scientific pursuit" was ineffective. People wanted a "caring environment"; they did not want to be experimented on. Advertising budgets in most of the demonstration markets have risen considerably in the last 5-8 years as declining occupancy and per case reimbursement force hospitals to scramble for patients. But in the field of bypass surgery, referral networks have always played a dominant role. Hospitals are experimenting with novel approaches that are evolving out of direct advertising to managed care negotiations as these plans proliferate.

12.5 Managed Care Contracting

All four sites were actively engaged in managed care contracting. Some had developed their own HMOs. Three of the four, excluding St. Joseph's Hospital in Atlanta, had Physician-Hospital Organizations (PHOs) of varying kinds. The Allegiance, as the PHO was called in St. Joseph's Mercy Hospital in Ann Arbor, worked with physicians in building a new data system to manage patient risk, develop clinical profiles, adjust global bid rates, and assure quality of care. These joint ventures have also been used to develop best practice protocols in order to keep costs down and stay within the private global rates.

In some instances, such as Boston, the managed care has emphasized full capitation, and local HMOs have refused to negotiate with University Hospital on a global price for bypass alone. (It does have an exclusive capitated arrangement with US HealthCare.) They claim they want to reimburse physicians separately, as well, believing they can manage their services better. Bundled payment for a single procedure was also incompatible with their payment systems. In other sites, however, global procedure bundling is alive and active. St. Joseph's Mercy has two private global bypass contracts with First American Bank and Consumers Power. These contacts are for a broad heart package that includes valves, angioplasties, bypasses, etc. St. Joseph's in Atlanta has been even more successful, negotiating bundled heart packages with Prudential, Cigna, Delta, and Aetna. Their physicians established a single entity that routinely collects all physician bills and packages them into a single invoice. Again, the focus is on "super bundles" for DRGs 106, 107, 112, 124, and 125.

Like University Hospital in Boston, Ohio State Hospital has not been successful negotiating global heart contracts. Plans have approached the hospital about contracting for super bundles, but the surgeons have balked at including such diverse DRGs and 124 that deal with a variety of circulatory disorders. Also, private plans are asking for a detailed clinical data base that is not fully developed as yet.

Most demonstration hospitals were quick to credit the Medicare program with their success in the private market. Where they have been successful in negotiating private contracts, financial officers have "expensed the experience" and cost of setting up the infrastructure under the demonstration. Now, private contracting requiring merged data management and billing processes are already in place.

12.6 Competitor Perceptions

Competition for bypass patients has increased dramatically over the past ten years for three principal reasons. First, many more hospitals are performing the complex operation. Second, the introduction of angioplasty has siphoned off many patients that would have been candidates for bypass surgery. And third, the almost complete disappearance of cost-based reimbursement of hospitals in favor of per case reimbursement and private capitation has made them far more volume conscious. Certainly, competition was quite keen in all four sites--even moreso than when the demonstration applications were first reviewed nearly five years ago.

Staff at the two competitor institutions were quick to point out the emergence of new hospitals, managed care plans, and catheter labs that made their job more challenging. Their responses are presented under seven headings.

12.6.1 Competitive Barriers in Academic Medical Centers

Two of the demonstration hospitals were academic medical centers devoted to teaching and research. One of the competitors that was interviewed was also an academic medical center. All three expressed common problems. First, all three admitted that they lacked a primary care network so important now with managed care and per case payment in filling hospital beds. In the past, academic medical centers saw little need for such a network. They generally provided the most complex care in the community, and local physicians naturally referred all their difficult cases to them. With the diffusion of high-tech services to more hospitals, the near-monopoly position of these centers has eroded considerably.

Building primary care networks appears especially difficult for academic centers. A major barrier is the lack of hospital privileges by local physicians. Once referred, family physicians cannot see patients in the center and bill for their services, nor do they retain any oversight for the patient's care. These centers also have a reputation for impersonal care delivered mostly by residents that discourages referrals as long as a viable choice exists elsewhere in the community.

Even recognizing the need for a network has been slow. One respondent admitted that the medical school dean "didn't see the need to build a primary care network" until the hospital experienced serious volume declines. Managed care plans were taking patients out of their hospitals because they could not provide the full spectrum of care. And without patients, there is no teaching and no research. At some point, university administrators have had to reemphasize the clinical side of their practices and have begun setting up satellite facilities and buying up practices. They are often woefully behind their private competitors, though.

The cumbersome bureaucracy inherent in an academic medical center, most respondents have noted, puts physicians at a distinct competitive disadvantage. With so many independent fiefdoms to satisfy, coupled with university requirements for privileges, credentialling, salaries, and contracting, referring physicians and managed care plans "just go elsewhere". In a few instances, the center's cardiovascular physicians have formed a Heart Center to negotiate global contracts with private plans. After lengthy discussions, the Heart Center has been delegated authority to negotiate capitated rates covering a range of related services for many specialty groups. Academic centers without these institutes remain at a serious disadvantage in a fast-moving market.

Another advantage of the institute structure is its ability to implement more efficient practice patterns. A prime example of this are the critical pathway protocols. Without them, it is difficult to streamline the care of bypass patients and coordinate specialty care at key points. A difficult issue has been the perennial cross-subsidization of financially weak specialties. With declining volumes, an institute arrangement deals with this problem explicitly.

One of the academic medical centers in the demonstration has had difficulties retaining is specialized heart staff, including thoracic surgeons, anesthesiologists, and invasive cardiologists. Often, the more entrepreneurial physicians leave the hospital to practice in a competitor hospital where incomes are determined more directly on work effort and clinical care. This is another way in which academic medical centers are at a disadvantage; namely, in the competition for highly paid heart specialists.

12.6.2 Growth in Competitive Catheter Labs

Coronary bypass patients are triaged in large part depending upon where they have their angiography. Over time, many new catheter labs have opened, radically changing existing referral patterns that favored the major medical centers. Early on, catheter labs existed almost exclusively in these centers. As more smaller hospitals adopt the service, local cardiologists have more discretions in where they will refer patients for bypass surgery. Even more significant, recently, is the addition of invasive cardiology and angioplasty. This further alters referral patterns, generally to the detriment of the large academic medical centers. Without strong primary care networks referring patients to the center for diagnostic angiography, and possibly bypass surgery, medical centers have seen more and more patients treated in smaller community hospitals.

One solution is to allow local cardiologists access to the medical center's catheter lab. But these labs have been closed to outsiders who lack academic credentials. Naturally, these cardiologists have gone to other local hospital labs, or started one in their own hospital, thereby siphoning off more potential cases.

One manager of a catheter lab in the demonstration felt it was an advantage that the medical center had a statewide reputation and referral network. He believed that the opening of labs in the local market, therefore, had little effect on the hospital's heart volume. While true, the fact that the medical center drew on patients statewide also meant its referrals were affected by the opening of a new lab anywhere in the state. In effect, the far-flung reputational network of the academic medical center has narrowed markedly in recent years. Most centers have had difficulties responding to this fundamental change requiring more attention to local markets and services.

12.6.3 Marketing Strategies

One of the competitor hospitals was surprised that the demonstration hospital did not do more local advertising. Instead, it chose to promote itself nationally to a greater extent. And when it did advertise locally, it emphasized quality over price, even though competitors felt that it was selected primarily on its low bid price.

This suggests that a demonstration hospital's advertising strategy depends upon who it is. Generally speaking, an academic medical center does not need to advertise its quality, especially statewide or nationally. What is more at issue is the costliness and impersonality of its care. It needs to advertise its familiar, accessible care at reduced costs. The demonstration hospital promoting itself nationally felt it important to convince patients, employers, and

insurers, that it was an equally high quality institution without the expensive academic relationships. In this regard, it was quite successful.

The observation that it did not advertise its selection and low prices more extensively is probably true. The hospital realized that referring physicians and managed care plans determined where patients would go. Certainly, general advertising to the public on price falls on deaf ears, especially for expensive heart bypass surgery. The place to discuss price is in private meetings with employers and managed care representatives. This kind of promotion is not nearly as visible to competitors, although they learn by losing contracts to lower cost bidders. The two non-academic participating hospitals have been quite successful in wooing plans through their lower prices, aided by the imprimatur of being a Medicare Bypass Center offering high-quality care.

12.6.4 Potential Conflicts of Interest in Joint Cost Sharing

One of the competitor hospitals felt that surgeons in the demonstration hospital faced conflicts of interest in receiving bonuses for reducing hospital costs. Indeed, staff claimed that "physicians at [x] were laying off nurses to get larger bonuses". The ethics of physicians sharing in cost savings is a thorny one, and many practitioners have questioned joint hospital-physician contracting and even HMOs as unethical.

The crux of the argument stems from the fact that physicians traditionally have considered the hospital their "free workshop". Physicians make practically all the key diagnostic and treatment decisions without bearing any of the institutional costs. Some have argued that this is as it should be. Only if support services are free will physicians make optimal decisions regarding the patient's welfare.

This argument has definite theoretical flaws and has been used to explain overtesting, too much surgery, iatrogenic illness, and unnecessarily lengthy hospital stays (Pauly, 1980; Harris, 1977). Physicians every day make decisions on diagnosis and treatment that balance costs with benefits, including the cost of their time and the patient's time. To ignore the most expensive input to bypass surgery, i.e., institutional costs, creates a severe bias in favor of hospitalization and reduced physician input.

On a practical level, the conflict-of-interest argument is becoming increasingly academic. Managed care plans are putting physicians at risk for both primary and institutional care. This is the way it must be because they make the decisions that allocate resources.

Have physicians under the demonstration laid off nurses for more bonuses? In the two nonacademic hospitals, physicians have received financial bonuses or other pecuniary returns for reducing ICU stays, working with clinical staff to shorten routine stays, conserve on tests

and consulting visits, and substitute less costly drugs. Whether they changed their practice patterns for financial gain is impossible to say, although there is no reason to believe they would have supported such changes in lieu of the demonstration. The more pertinent question, of course, is whether the changes were cost effective. From our empirical analyses of patient outcomes, it appears that patients have not suffered from the cost reductions; thus, it would appear that demonstration surgeons have introduced more cost effective treatment methods.

12.6.5 Gaming the Demonstration

Another concern voiced by competitors, at least in one site, was that surgeons may be gaming the demonstration by selectively operating on easier cases. Some thought they may be taking less difficult cases as a few very difficult cases were referred to the competitor. It is admittedly difficult to measure case severity given variability in coding comorbid conditions. Lung, liver, and stroke problems can be "overcoded" to appear to be operating on more serious cases. Interestingly, in another site, the competitor believed that surgeons in the demonstration hospital may be taking on cases that were too risky. Addressing this concern would require independent examination of the medical records, and even then it would be difficult to validate the accuracy of the record. In the evaluation of patient outcomes, a glossary of definitions for comorbid conditions was provided clinicians, but it is unclear how assiduous they were in following the guidelines.

Another gaming strategy that was mentioned involved reclassifying expensive patients outside the demonstration. With the redefinition of most bypasses from DRG 108 to 106-7, this potential problem would appear to be minimized. Nevertheless, staff at one competitor was concerned that bypass patients might be dumped into DRG 468 if unrelated procedures were done during the same admission. They also wondered if demonstration surgeons were keeping patients on ventilators an overly long time in DRG 467, thus exempting them from the demonstration. It is not clear why these patients would be reclassified out of DRG 106 or 107 in the first place. In any event, the possibility of surgeons gaming the global rates by selectively eliminating patients from the demonstration needs to be carefully examined.

12.6.6 Disappointment with the Application Process

One competitor was quite upset with the government's handling of the selection process. First, as a losing applicant, they were disappointed to see that other hospitals with higher rates were accepted into the demonstration. Second, when the government adjusted the

payment rates for the four participating hospitals for more expensive DRG 108 bypasses, one competitor felt that the selection should have been reopened to the other applicants. To them, this constituted a significant change in the patient sample. Whether this was reason enough to reopen the selection is debatable, but eventually HCFA invited all six losing finalists to submit new applications. Three did so and were included in the second round.

13.0 CASE STUDY FINDINGS: HOSPITAL PAYMENTS TO PHYSICIANS

13.1 Introduction

When HCFA solicited proposals from applicants, the Agency requested that a global price be offered that covered all institutional and physician costs for Medicare patients undergoing bypass surgery. The Agency also insisted that the proposal be presented in two parts reflecting the programmatic split between Part A, Hospital, and Part B, Physician. This was done in order to accurately determine the patient deductible and copay amounts which vary across Part A and B. It was also necessary to appropriate demonstration outlays between the two funding sources. Applicants were also told that how they decided to split the global payment with physicians was entirely their decision. They did not have to follow existing payment rules under Medicare and could offer HCFA different discount rates on hospital and physician services. Moreover, they could change their split any time they wished, although HCFA's global payment and estimated patient copayments would be unaffected.

A more detailed description of how the Agency evaluated the proposals was included in Chapter 3 of this report. In summary, hospitals knew exactly what Medicare was paying them for DRG 106 and 107 patients, although they did not know with any certainty how much their bypass patients were actually costing them. At least the four hospitals had accounting systems (of varying degrees of accuracy) that allowed them to make independent estimates of their institutional costs.

By contrast, no system existed to track physician payments for inpatient services provided to bypass patients, let alone the "cost" of physician services. Physician practices simply do not "cost out" patients. The reason is simple. In bypass surgery, the bulk of costs are bound up in thoracic surgeon and cardiologist time, neither of which has a fixed wage rate per hour. Physician payment is generally a residual after other expenses have been met. This is true even in the two academic medical centers where salaried physicians enjoy additional distributions of practice funds at year's end. Medicare Part B physician payments, however, were available, although no centralized data base existed in any participating hospital at the beginning of the demonstration. Part B databases have been developed as a natural outcome of submitting bundled packages of bills to HCFA for payment. Therefore, in lieu of extant data, hospitals either collected bills from physicians involved with bypass patients and calculated average Medicare payments or accepted physician estimates of payments.

On the other side of the negotiating table, HCFA had the advantage of having national Part A and B bill records that could be used to estimate average payments per bypass patient in each of the hospitals. When it came to negotiating rates, some hospital administrators were

surprised to see how little HCFA was paying its physicians, on average, for its DRG 106 and 107 patients.

Several policy and technical issues concerning the division of HCFA's global payment between hospitals and physicians are worthy of study. First, can and will hospital managers and physicians work together to submit a global bid and participate in negotiations where both groups offer discounts? The demonstration has already answered this question in the affirmative. Second, how do the two groups arrive at their original bids and settle upon discounts? Third, over time, does cost-sharing occur between the two groups? Fourth, if efficiency gains are realized by physicians in their treatment of bypass patients, are they recognized in their split of the global payment? In another vein, during the first year of the demonstration, the Congress passed legislation rolling back several procedure prices pertinent to bypass surgery. These rollbacks required HCFA to reduce the Agency's global payment in future years by an actuarial amount equal to the share of these procedures in the total payment. HCFA also made adjustments in the Part A component for changes in relative values, local wages, etc. Thus, a fifth policy question is how hospitals responded to these payment adjustments splitting the global payment. Sixth, did any technical changes in care or mis-estimates result in payment shifts? And seventh, how quickly have hospitals paid physicians once they performed a service under the demonstration?

13.2 Organization of Interviews

Several persons were interviewed concerning how physicians were paid under the demonstration. The key informant was usually the manager of the demonstration. Also interviewed were the CFO and persons responsible for billings and collections on the hospital side. Counterparts on the physician side, including thoracic surgeons, were also interviewed. (See Appendix 10 for the interview protocols.)

13.3 Setting the Initial Payment Level

Four specialties were regarded as integral to the care of bypass patients. These included the thoracic surgeon, the cardiologist, the anesthesiologist at surgery, and the radiologist. These four specialists would invariably receive a fixed capitated payment for every demonstration patient regardless of services required. Rates varied by DRG, with cardiologists receiving far larger payments when patients had their angiography performed in the demonstration hospital (in DRG 106).

Determining how much to allow for other consultants proved far more challenging to hospitals because patients varied in their requirements for consulting services. Based on limited billing information, hospitals developed rough estimates of how much to set aside of the global payment for consultant bills. The usual policy was that consulting physicians would bill the hospital using Medicare allowable fees. They were never allowed by HCFA to bill carriers directly. They had to be paid directly by the hospital out of the global payment. Payments to consultants came from a set-aside in the capitated amounts of the four principal specialties involved in every case.

Hospital administrators negotiated initial discounts with surgeons and cardiologists that varied considerably by applicant. After further face-to-face negotiations with HCFA staff, the two groups reevaluated their original estimates of Part A and B costs and established fixed rates. Physicians tended to overstate average Medicare *payments* as distinct from their charges. For surgeons, the only variability in Medicare allowable payment involved the number of vessels bypassed, making the hospital's task easier. For other physicians who provided a mix of services, such as cardiologists, the setting of a global average payment was more difficult. Some hospitals were able to obtain more comprehensive payment information from physicians than others. The lack of complete bills and payments created tensions later on when final rates were negotiated with HCFA and distributions of the global payment began.

In the beginning of the demonstration, none of the four original hospitals had any formal rules for changing the negotiated rates with physicians, although a couple said they would wait and see what happened to hospital costs. This was before the RBRVS procedure rollbacks mandated by Congress led to reduced global rates. Other administrators said they had no intention of changing the split because of the large discounts already offered by on the Part A portion of the global bid. There seemed to be considerable skepticism that surgeons would or could achieve significant cost savings for the hospital.

13.4 Changes in the Hospital-Physician Split of the Global Payment

Over the course of the demonstration, the proportion of the global fee paid to physicians increased in all four hospitals for three reasons:

(1) Technical changes and Mis-estimation;

(2) Implementation of RBRVS and adjustments to the Part A component;

(3) Bonuses and in-kind payments.

13.4.1 Technical Corrections

In one hospital, the average payment to radiologists was ratcheted downwards after the rate was determined to be excessive. According to hospital administrators, the error was discovered after cumulating a number of radiologist bills on several demonstration patients and comparing the average Medicare allowable with the radiologists' original estimate.

By contrast, analysis of submitted claims on demonstration patients in the same institution resulted in an increase in the average cardiologist payment for DRG 106, with an offsetting reduction in DRG 107. Because the catheterization is such a large part of the cardiologist payment for DRG 106, and given that only certain cardiologists perform the angiography while other cardiologists may provide medical care on a case, it was also decided to pay separately for the catheterization. It was relatively easy to carve out this procedure for separate payment because it is always made for DRG 106 patients and never for DRG 107 patients.

13.4.2 Adjustments for RBRVS and PPS

Implementation of RBRVS payment rollbacks for overpriced procedures presented a special challenge to the demonstration. First, HCFA staff had to make an actuarial determination of the effect of the rollbacks on each hospital's global payment. This involved taking the changes in Medicare allowables for each market area and applying percentage reductions to the global payment, weighting the change in each procedure's price by its share of the global payment.

From interviews with participants, it appears that none of the surgeons or other physicians in the demonstration had their average payment reduced because of mandated changes in the Medicare Fee Schedule. That is, all physicians have been sheltered from the overpriced procedure rollbacks and continue to receive at least what they were being paid by Medicare prior to the start of the demonstration; often more. This produced an implicit shift in the split of the demonstration global payment away from hospitals towards physicians.

Surgeons at most of the hospitals argued that they had already offered a significant discount (estimated to be between 10-25% by surgeons in two institutions) and felt they should not have their fees ratcheted down even more for RBRVS. In three institutions, hospital administration seemed comfortable with maintaining physician rates at their original levels, but the issue of the payment split was quite contentious in the fourth institution. Having offered very large discounts on the Part A side, coupled with a failure to generate any volume growth over which to spread fixed costs and overrunning consultant bills, hospital

management asked surgeons to absorb the RBRVS reduction. They refused, arguing that the hospital had "signed a contract" for a fixed payment, as had the other specialists, and everyone should "stick with it [the payment split]". Surgeons argued successfully with the hospital that they had already offered a significant discount and should not have to reduce their fees even further. The hospital, of course, could make a similar argument.

HCFA has also made adjustments in the global payment for changes in the hospital prospective payments for the two demonstration DRGs. This has resulted in lower average payments, particularly for DRG 107 which had a significant reduction in its relative value. Rates have been increased based on the PPS market basket, on the other hand (see Chapter 3).

In spite of reductions in global payments, all surgeons and cardiologists in the demonstration have been insulated from any reductions in specialists fees or PPS adjustments taking place in their market areas. (In fact, some have done much better than that because of bonuses and in-kind payments, as discussed below). In three of the four hospitals, it appears that surgeons, who comprise half the DRG 106 payment to physicians and 60% or more of DRG 107, have had their base rates (before bonuses) fixed over the period of the demonstration. Thus, while they have not experienced any RBRVS rollbacks, they have not had their fees updated for inflation either. Cardiologists in at least one of these hospitals, on the other hand, have seen their average payment increased 30% to correct an original mis-estimation, leaving the overall financial split between the hospital and physicians unchanged.

13.4.3 In-kind Payments and Bonuses

Sheltering surgeons against large RBRVS rollbacks has been one definite advantage of participating in the demonstration. Beyond this, they have enjoyed other benefits in two institutions. In one case, surgeons have received three valuable in-kind services as a consequence of the hospital achieving significant cost savings on bypass patients (including non-Medicare patients). First, the hospital made more operating room time available to them. A request for more time had fallen on deaf ears before the demonstration. Once surgical operating room times began to drop, the hospital responded by improving access to the cardiovascular surgeons.

Second, the hospital took over the salaries of the surgeons' physician assistants, who had been previously employed by the surgeons themselves in the operating room. This may amount to a $40,000 savings annually for the practice; possibly more. Besides the employment change, no other change was made in the way surgeons used their assistants. Hospital management felt it made sense to convert their surgeons' assistants to hospital employees in that they were working full-time either in the hospital's operating room or seeing hospitalized

patients pre- and post-operatively. Naturally, working under a combined global payment was key in the hospital's thinking. Either the hospital paid for them directly or indirectly in the physician's portion of the payment. Besides, the surgeons had more than paid for the switch from a savings elsewhere in the hospital.

A third way the hospital helped surgeons was by taking over the salaries of the clinical nurse specialists who used to work for the physicians managing their patients before and after hospitalization. Again, the hospital felt that these nurses should work for the hospital if they were actively implementing critical care pathways in the ICU and elsewhere in the facility. Also, they were more than paying for their salaries through institutional cost savings.

One hospital in the demonstration went a step further and is now providing cash bonuses to physicians who practice in a more efficient manner. The hospital implemented its Cost Reduction Allocation Program for cardiac surgeons designed to reward surgeons differentially for their efforts in reducing hospital costs. Once physicians had demonstrated their willingness and ability to materially reduce costs, hospital administration recognized their efforts by developing a formal method of sharing the savings. The program works as follows:

(1) **Eligibility Criteria:**

To be eligible for any cost sharing, the surgeon must meet minimum quality standards, defined as:

(a) Falling within two standard deviations of the average hospital-wide bypass surgeon rates on mortality, complications, returns to the operating room and ICU, readmission rate, and use of consultants;

(b) The overall results of a hospital satisfaction survey of demonstration patients must exceed the overall hospital average; and

(c) A surgeon must perform at least 15 demonstration bypasses a year to be eligible.

(2) **Payment Rate:**

(a) In 1993, the surgeon received the greater amount of either:

(i) his current updated negotiated rate minus 3% but not further reduced for RBRVS reductions; or

(ii) a rate adjusted upwards for shared cost savings.

(b) The eligible surgeon's cost-adjusted rate (payment) under (ii) would be equal to PAYMENT = RBRVS + .25*HOSPITAL COST SAVINGS

(c) Hospital cost savings are defined as the difference between the surgeon's actual average hospital cost per bypass in 1992 minus the expected cost under normal inflation and intensity increases. Savings are further based only on the hospital's variable costs (which are determined to be roughly 60% of 1993 average costs in the facility, see Table 6-1), assuming these costs are under the surgeon's control.

Thus, under the allocation program, all surgeons are protected from RBRVS rollbacks by receiving at least their original negotiated rate under the demonstration, with annual updates, minus -3% for a minimum efficiency gain. Surgeons can earn more than their original rates if one-quarter of their savings in hospital variable costs, when added to the RBRVS allowable, exceeds the original amount that they would have received.

According to the manager of the demonstration in this hospital, some surgeons averaged over $3,600 in hospital variable cost savings per case in 1990-92. This translates into $900 in extra payments per case over-and-above what they would have received if they had been under the Medicare Fee Schedule. Based on the surgeons' negotiated rate with the hospital at the beginning of the demonstration, this amounted to roughly a $400 increase per case at a time when Medicare bypass fees were falling nation-wide.

Payments to cardiologists, radiologists, and anesthesiologists appear to have had their rates fixed, at least between 1992 and 1993, but they were not reduced due to RBRVS. As happened in another institution, separate rates are paid for invasive versus noninvasive cardiologists involved in DRG 106 cases. The payment differential is 4:1.

Payment to consulting physicians is made on a flat, capitated rate, basis, but only if they are involved in the case. Pulmonologists are subject to the flat amount for less than 20 visits with a patient. Beyond 20, they are paid on a fee-for-service basis.

13.5 Collecting and Paying Patient Copays and Deductibles

Under Medicare Part B, physicians must bill patients for any deductibles or copays. When the global rates were negotiated between HCFA and the hospitals, an actuarial average amount representing the patient's obligation was determined for DRG 106 and 107, separately, and taken out of the amount paid directly by HCFA Central Office to the hospital. HCFA was silent on who was responsible for collecting the single coinsurance amount.

The responsibility for collecting the patient portion of the global fee fell in all cases on the hospital. Physicians no longer were responsible for trying to collect the Part B deductible and copays either directly from patients or from their supplemental insurers.

Collection of the supplemental coinsurance payments from insurers has been very onerous for hospital staff. Physicians have been sheltered from all of the difficulties, however, through prompt hospital payment. In the one hospital using a formula to pay bonuses for efficient practice, its total payment to physicians also includes an estimate of the extra amount that it expects to collect from third party payers. It is assumed that 87% of patients have supplemental insurance. Based on hospital experience of collecting 70% of the maximum allowable copay, a fixed amount is added to the RBRVS program payment and any bonuses the surgeon is eligible for. The other three hospitals appear to be paying physicians the full amount of the patient deductible/copay calculated by HCFA.

Not only are physicians not held responsible for collecting patient obligations, they are being paid the supplemental amount even before it is collected by the hospital. In the two nonacademic medical centers, physicians are being paid immediately for all of their portion of the global rate, excepting any set aside for consultants, plus any bonuses. This payment occurs either upon discharge or after the principal surgeon, anesthesiologist, and cardiologist bills are submitted to the hospital for inclusion in the packaged invoice to HCFA Central Office.

In the two academic hospitals, physicians are reported to be paid within two weeks of discharge. In one of these hospitals, radiologists are being paid only after HCFA pays the hospital due to slow submission of their bills.

The cash flow advantage to physicians of the hospital paying the program and supplemental insurance payment promptly is significant. Many physician practices are accustomed to submitting bills for payment the day after the procedure is performed even before the patient is discharged. Under the demonstration, no physician can bill third party carriers or supplemental insurers, but rather, must direct their bills to hospital accounting. Once the patient is discharged and a minimum of three significant bills are submitted, the hospital can forward the package for payment. This often takes several days after discharge. Payment is made by HCFA within 30 days, according to hospital billing/collection department staff. Were physicians required to wait until the hospital was paid the government's portion of the global rate, payment lags could be triple what they ordinarily would be. Delays in updating RBRVS rates creating an additional lag in 1994 payments of three months, according to hospital staff. Physicians, again, were sheltered from these delays as the hospitals continued prompt payment.

Delays in collecting the supplemental insurance have been far longer than from HCFA, averaging 3-4 months, if payment is ever made. (See Chapter 15 for details on the problems of collecting the supplemental insurance.) According to hospital financial managers, the hospital has been responsible for collecting these extra payments with no delays to physicians.

13.6 Conclusion

From the way physicians are being paid under the demonstration, it appears that they have been financial winners for the most part, with the notable exception of consulting physicians. All physicians have been sheltered from RBRVS rollbacks over the last two years. Surgeons practicing in the two nonacademic medical centers have enjoyed significant bonuses, either in the form of in-kind benefits or supplemental bonuses to their negotiated rates. These also are the two institutions with the largest facility savings under the demonstration. All physicians have been sheltered as well against any delays in receiving HCFA program payments or supplemental insurance payments.

Surgeons and cardiologists, it should be noted, have earned preferential treatment in three of the four hospitals. They have introduced many cost saving changes in clinical practice that have made demonstration patients more profitable to hospitals. Indeed, because these changes extend to non-demonstration bypass patients as well, hospitals are saving even more money than suggested by figures for the demonstration alone.

14.0 CASE STUDY FINDINGS: HOSPITAL ACHIEVEMENT OF PARTICIPATION GOALS

14.1 Introduction

In Chapter 3, several different reasons were offered initially by participants for participating in the Medicare Heart Bypass Demonstration. Competitive pressures were cited as one reason for joining the demonstration. All four original hospitals had good reasons for wanting to protect or expand their current market shares. Another reason for participating was the hope that the Medicare demonstration imprimatur would increase volumes and hospital profits. While the participant would be receiving less than they might have under Medicare prospective payment for DRG's 106 and 107, the extra volume, it was hoped, would add to the hospital's (and physician's) bottom line. A third reason for participating, less often mentioned than others, was to reduce the costs of care. This could be accomplished, hospital managers believed, either by implementing more efficient hospital management methods under the incentive of a lower negotiated payment rate, and/or by bringing physicians under the same bundled payment rate and forcing them to internalize hospital costs.

In this chapter, the reasons each hospital had for participating are reviewed in the light of nearly three years experience under the demonstration. It is important to evaluate the demonstration's success from the participant's perspective for several reasons. If participants are satisfied with the outcomes, they are likely to continue. More importantly, satisfied participants would encourage other hospitals to accept a single bundled payment. On the other hand, if participants are disappointed with some aspects of the demonstration, it is important to understand why. The design of the payment scheme might be improved based on feedback from participants. Failure to achieve all goals may also derive from barriers or constraints within the participating institution or from competitive responses on the part of nonparticipating hospitals. Knowing the source of the disappointment or satisfaction speaks to the generalizability of the demonstration to the rest of hospitals performing open heart surgery. Certain hospital or area characteristics may be more conducive to expanding bypass caseloads and market shares. In hospitals and markets with similar characteristics to those in the demonstration, program effects may also be similar, although with just four original demonstration hospitals, generalization is limited.

14.2 Organization of Interviews

Extensive interviews were conducted with the key decision makers in each participating institution, including the

- Chief Executive Officer,
- Chief Operating Officer,
- Chief Financial Officer,
- manager of the demonstration,
- Vice-president in charge of government affairs,
- managers of marketing
- managed care contracting.

In addition, we interviewed the

- head thoracic surgeon

at every hospital regarding the reasons physicians decided to participate and how successful the program had been in their view. In every hospital, one or more of the respondents was involved in the initial decision to participate in the demonstration. These persons were key because they were most knowledgeable about the original goals and could speak to the overall success of the demonstration from the beginning.

During the time of the demonstration, very little turnover occurred at the top decision-making levels. All four CEOs remained, and almost all of the CFOs and COOs continued in their positions. All four hospital managers of the demonstration remained with the hospital as well, although three left for other positions in the industry shortly after the first three years and a fourth retired.

Each person was asked to review the reasons for participating in the demonstration and whether their original expectations had been realized. (See Appendix 10 for the interview protocols.) Goal areas given special attention included changes in volumes and market shares, management of costs, organizational changes, and hospital-physician relationships.

14.3 Volume Growth and Market Shares

Of all the demonstration goals, volume growth was probably paramount in the minds of participants as well as HCFA. The imprimatur of being named a Medicare Heart Bypass Demonstration hospital, even without any guarantees of exclusivity in local markets, was expected by most participants to result in more bypass patients being admitted, accompanied by a shift in market share in their favor. As shown in Chapter 4 above, two of the four hospitals in Atlanta and Ann Arbor did achieve significant volume and market share growth. The two academic medical centers in Boston and Columbus, Ohio, did not. In the two sites with significant growth, there was a difference of opinion about how important the demonstration was. In Atlanta, most of the key hospital and physician staff believed that the designation helped considerably in increasing volumes. It did so, respondents believed, because the hospital was now viewed as a true Center of Excellence with a national reputation for treating heart disease it lacked before the demonstration began. In Ann Arbor, the feeling was that the cardiologist network played a more important role, being very active in the southwestern part of the state. In fact, one physician felt that the demonstration may have had a chilling effect on some referring physicians who were philosophically opposed to surgeons working with the hospital under a single bundled payment. It is impossible to evaluate this assertion, but there is no doubt that all four hospitals and their physicians met considerable hostility from some competing hospitals and physicians who were opposed to the concept of a bundled payment and the alignment of hospital and physician incentives.

The two academic medical centers that failed to achieve significant volume gains were also of two minds as to why they didn't realize this goal. In Boston, the participating hospital had relied fairly heavily on a distant referral network in Albany, New York, and Manchester, New Hampshire. Both of these shrank considerably with the introduction of bypass surgery capabilities locally. The demonstration had nothing to do with the large loss in patients, and may have helped replace the deficit in the local Boston market. Survival under such circumstances was viewed as a positive aspect of being in the demonstration. As a minor performer of bypass surgery in a very large market dominated by several academic medical centers, University Hospital has always been as much concerned about maintaining its market as it has about taking patients away from its competitors. Being named a demonstration hospital conveyed some prestige, but in Boston several other heart hospitals enjoy even more prestige and growth in market share would be unreasonable to expect without an exclusive arrangement. Roughly constant volumes, respondents felt, was an achievement of some sort. Interestingly, hospitals that did see their shares grow were not the most prestigious,

suggesting that the Medicare imprimatur was not as important as other factors in this highly competitive market.

In Columbus, Ohio State University Hospital is in a somewhat different situation being the only academic medical center in the city. While strides have been made in organization and patient care management, the hospital's failure to achieve significant volume growth was disappointing, especially given the deep discounts it offered. According to one physician, an ambitious goal of 1,000 bypasses (Medicare and non-Medicare) was set at the beginning of the demonstration. In 1993, the hospital performed only 443, or slightly more than one a day. Reasons for the failure were many. Some physicians were unhappy with the quality and aggressiveness of the hospital's marketing efforts. Some felt that HCFA had abandoned the hospital by not promoting the demonstration and had misled them about the right to waive patients' deductibles and copays (which they could not). Still others felt that the turnover among surgeons and other key physician staff prior to the demonstration had a long-run impact on volumes.

14.4 Private Managed Care Contracts

An unexpected benefit of participating in the demonstration developed in the area of managed care contracting. When the demonstration began in early 1991, virtually no private payers were negotiating bundled surgical packages. Immediately afterwards, payers in three of the four sites began developing global pricing products and negotiating with hospitals for exclusive contracts. In Atlanta, in particular, the publicity, along with the changes in physician practice patterns engendered by the demonstration, led directly to other private global packages. The Delta package was cited as one, highly visible example that hospital management believes would have been difficult to secure for a nonteaching hospital without the imprimatur of the demonstration. The spillover effects of the demonstration on private managed care global payment contracting, therefore, should not be underemphasized, however difficult they may be to quantify.

14.5 Cost and Patient Data Bases

Three of the four participating institutions also believed that the demonstration had spurred them to improve their cost and patient data base systems. Both physicians and hospital managers recognized that their existing data systems were either inadequate to measure the true cost of demonstration patients or were not being used to their full potential.

In particular, detailed micro-cost information on the patients of individual surgeons was not generally available.

Two of the four hospitals either had a micro-cost system in place or were finalizing its implementation. One other hospital, realizing the inadequacy of its old costing system, adopted a micro-cost system and began producing reports after two years. A fourth hospital has rejected a detailed micro-cost system as too expensive, too complicated, and taking too long to implement.

The importance of accurate, detailed, costing systems to a participant's success in the demonstration cannot be overemphasized, as explained in Chapter 11. Changing physician behaviors by making them more cost conscious requires accurate, procedure-specific data presented in meaningful reports. The two are not synonymous. A hospital can have an excellent micro-cost system but lack ways of reporting costs to physicians to support useful discussions of practice pattern differences. This was often the case. But to the participants' credit, all four contracted with an outside consulting firm to merge cost and patient information and provide comparative data from other hospitals. Armed with these reports, the firm's staff worked with physicians on areas where they were shown to be outliers and how savings could be made by reducing the time from "cath to surgery", in pharmaceuticals, in ICU time, in the use of consultants, and in contrast agents in the cath lab, to name just a few. Physicians work in a micro world, one patient at a time. Each patient is viewed as different, requiring different services. But when services are properly costed, then aggregated across each physician's caseload, patterns emerge among clinicians that were unknown or only vaguely understood. Once patients are stratified by meaningful risk and severity factors, e.g., previous bypass, age, etc., surgeons can talk more precisely about variations in resource and drug usage among themselves and with their colleagues in anesthesia and cardiology.

More disaggregated cost data by type of patient has also helped managers do their job better. Only in the last ten years have administrators become immersed in the arcane area of practice patterns. Under cost-based reimbursement, there was no need to know what different patients cost or why costs varied so much for similar patients in the same institution. DRG per case reimbursement forced managers to take an interest in the cost of the "bundle" of services across the entire admission. Not only that, but to focus on the costs of specific conditions. A single bundled payment, that includes physician services as well, goes a step further in bringing clinicians into the management loop.

Under the demonstration, administrators and clinicians worked together to produce meaningful reports and to understand how to make practice patterns more efficient. In order to do that, nonclinician administrators needed to learn much more about coronary artery disease, angioplasty, and bypass surgery, and why costs might vary among patients. While

hospital staff became more knowledgeable at all four sites, in only two sites did the manager of the demonstration appear to have an intimate working knowledge of the management of coronary artery disease. In general, managers delegated responsibility, probably appropriately, to clinicians and nurses who were given responsibility for working with physicians and department heads to make patient care more efficient.

Even in the hospitals with excellent micro-cost systems, the analytic reports that were produced fell short of what could have been done. Surgeons in all four hospitals maintained clinical registries on their bypass patients. While these registries were deficient in a few respects, they contained a wealth of information on patient risk factors, severity, disease anatomy, extent of surgery, complications, and outcomes. Yet, no hospital appeared to have merged their micro-cost data with the clinical registries and stratified costs by patient characteristic at the patient level. Hence, none were able to say, for example, how much more costly a patient was who had had a previous bypass before entering the demonstration, or why such patients were more costly. And while the micro-cost data base could distinguish the use of generic fentanyl from the expensive brand name, Sufenta, as a surgical anesthetic, hospital staff were unable to stratify patient outcomes using the two drugs by key surgical risk factors to show clinicians the costs versus outcomes. (Actually, pharmacists in one hospital did conduct such an evaluation, but not through a merger of the two data bases and extensive adjustments for patient risk factors.)

The one hospital that failed to invest in a detailed micro-cost software encountered major problems in changing clinician behavior. Physicians felt that the inability of administration to tell them the true costs of tests and procedures was a sign of indifference regarding costs on the part of management or, worse, an effort to hide savings from them. The problem stemmed from the use of an antiquated cost reimbursement system based on cost-to-charge ratios at the department level. Spreading all direct costs in the operating room across a heterogeneous mix of operations and reporting an average cost for bypasses alone, obviously has little meaning if one is trying to change practice patterns for a specific procedure. The treatment of indirect overhead costs was also controversial, and physicians felt costs were being overstated. Finally, physicians were aware that the old cost-to-charge system had been manipulated by hospital accountants to maximize reimbursement under cost-based payment in ways having little to do with the true costs of care. To simply apply it to costing bypass surgery patients raised serious questions regarding its verisimilitude. To management's credit, they have now seen the value in upgrading their micro-cost system and are in the process of implementing a new system.

Besides supporting the improvement of internal management, administrators in all four hospitals felt that micro-cost systems, married to key patient demographics and medical record

information, were critical in negotiating managed care contracts. Unless a hospital and physicians had solid estimates of true patient costs, especially variable costs, they were at a disadvantage in negotiating global payment rates with local managed care plans. Those with such systems said that the private sector, liked to see managers and physicians take an active interest in costs and practice patterns for identified conditions, and back that interest up with numbers.

14.6 Cost Reductions and Efficiency Improvements

Without question, the most noteworthy achievement of the demonstration has been better cost management of bypass patients. In a time of 6-10% annual cost inflation, one hospital "set an ambitious goal of saving $1,000 per bypass patient, and we achieved it." Another participant was able to reduce variable costs by even more in absolute terms, in spite of rising wages, new and more expensive supplies, and the like. A third hospital's management, while not having the detailed cost data at hand, knew that practice patterns had changed and that lengths of stay, which had been abnormally long, had fallen significantly. All of these institutions ascribed the program's success to the alignment of physician with hospital incentives. Once physicians, and especially surgeons, recognized that their use of hospital resources was not "free" to them, they energetically reviewed the cost reports and discussed them with their colleagues to see where savings could be made. Indeed, in some cases, surgeons were ahead of hospital management in asking for particular reports.

Cost reductions were almost always the result of efficiency improvements in patient care management, although some efforts were made to negotiate lower product prices or make departments run better. These improvements, in turn, appeared to be the result of active surgeon involvement in patient management, reinforced by the implementation of clinical nurse specialists tracking patient flow. One hospital noted that shorter operating room times freed up time for other surgeons and allowed the hospital to reduce nursing staff.

A spillover effect of better cost management was also noted by administrators. When cheaper generic drugs were substituted for brand names, all payers benefited, not just Medicare demonstration patients. When ionic contrast media were substituted for nonionics in performing angiograms, all patients undergoing catheterization benefited from lower cost. The same is true with shorter ICU stays and same-day surgery admissions. Indeed, one hospital's managed care director believed that "many payers [in the city] were the primary beneficiaries of the demonstration in that they were able to negotiate total bypass packages on private patients, following the demonstration's lead, that saved $20,000 per case "

Once again, management in a fourth hospital was disappointed in the cost savings they achieved, although most felt significant changes in internal organization had taken place in the last year. Admittedly, when they began the demonstration, no financial goals were stated, implying that cost reductions either were not expected or not viewed as key to success. In fact, this hospital's strategy relied at first on increasing volumes and driving down average fixed costs. It was only when volume growth did not materialize that the hospital belatedly turned to internal cost management to avoid severe financial losses.

14.7 Physician-Hospital Alliances

All four hospitals entered the demonstration wanting to forge a closer relationship with their medical staffs. In most cases, this was true of surgeons as well. Even to apply to be a demonstration hospital required many difficult meetings over issues of bidding strategies, how the payment would be split, which specialists would be under the demonstration, etc. Hospital managers uniformly agreed that the advent of private managed care required that their medical staffs take a more active interest in hospital costs. Physicians, for their part, sought more marketing support for their own practices.

All four hospitals felt that closer hospital-physician alliances were an important achievement of the demonstration, although tensions still exist in one facility. Physicians and hospital managers have worked together in the demonstration like never before, exchanging cost and clinical information, developing marketing plans, building referral networks, re-evaluating the use of drugs and supplies, negotiating private global bundled payment arrangements, etc. Working together under identical financial incentives is perceived by all as key to building the alliance. It also has been challenging, particularly in changing practice patterns. Physicians are used to treating the hospital as their workshops with no financial responsibilities for nurses, operating room supplies and downtime, ICU telemonitoring, expensive brand name drugs, and the like. They have had to make many changes. In only one hospital has the relationship between surgeons and the hospital been an adversarial one at times. Yet, even there, changes have taken place. Managers and physicians have worked together on new clinical protocols, marketing efforts, and managed care negotiations.

As expected, the relationship between the hospital and consulting physicians deteriorated somewhat, although this varied depending upon the frequency of consulting visits before the demonstration began. Pulmonologists, radiologists, nephrologists, neurologists, and cardiologists in one hospital were very upset when surgeons began reducing consultations and managing patients post-operatively on their own. Claims of undertreatment and poorer quality were made in meetings with the hospital CEO. Management asked

consultants to verify their claims through quantitative studies. No such studies had been submitted at the time of our interviews, and the tensions have subsided as consultants accustomed themselves to lower referral rates.

14.8 Quality Improvements

No hospital entered the demonstration with even an unstated goal of improving the quality of care for bypass surgery. All four candidates were screened by HCFA on their quality before being accepted into the demonstration, and none felt they had quality problems to address. Nonetheless, hospital staff in one participating hospital believed that quality had been improved because surgeons were taking a more active interest in complication rates. Complications, more than any other factor, add to costs, possibly up to $1,000 a day for prolonged stays in the ICU. As surgeons focus on sources of complications, they have been able to avoid them, which is a win-win situation: lower costs and better outcomes. It should be noted that many complications to bypass surgery are not life-threatening but can add considerably to costs. By having a financial interest in minimizing the complication rate, regardless of severity, at least one demonstration manager felt that surgeons were enhancing quality.

14.9 HCFA and Private Supplemental Reimbursement

Besides the lack of volume gain in two of the sites, reimbursement problems constituted the other major disappointment to participants. This was true in all four sites, but especially in the nonacademic institutions. Although none of the sites had as a goal improvements in existing Medicare payment arrangements, the demonstration, when grafted onto the current system, increased payment problems enormously. All four sites have had to devote significant resources to the problem and see it as a potentially serious hindrance to the diffusion of the method nationwide. Chapter 15 discusses the problems in greater detail.

15.0 CASE STUDY FINDINGS REGARDING HOSPITAL REIMBURSEMENT DIFFICULTIES

15.1 Introduction

The Medicare Heart Bypass Demonstration required fundamental changes in the way hospitals and physicians were paid; changes due both to the bundled nature of the payment and the fact that it was a demonstration and not a complete restructuring of payment methods for the entire program. The payment arrangements were as follows. Each hospital negotiated a single bundled rate to cover all Part A hospital and Part B physician inpatient care. In order to receive payment, each hospital originally was responsible for bundling all Part B physician bills with the Part A UB92 discharge record and submitting the package to HCFA Central Office in Baltimore for payment. Local Fiscal Intermediaries and Carriers were instructed not to pay any bills submitted under the demonstration, nor were they to receive any. All program payments, excluding any patient obligations, were to come from Central Office. This was done so as to avoid double payment for services: once under the demonstration and a second time by FIs and Carriers.

At first, each hospital was expected to submit a package including all physician bills related to a given stay. Once received, payment was to be processed within 30 days. Because of hospital difficulties in assembling all the Part B bills, HCFA changed policies early on and authorized payment if the three principal bills of the surgeon, anesthesiologist, and cardiologist were submitted along with the discharge abstract.

Billing HCFA Central Office for payment was fairly straightforward. Collecting the patient financial obligation from third party supplemental insurers was not. When a bill was submitted to HCFA Central Office, HCFA then determined the extent of the patient's obligation for the Part A and B deductible and the Part B coinsurance of 20% of physician services. This determination is done routinely every day for all Medicare admissions. It requires searching the billing records to see if a patient has already met her deductibles on previous admissions and physician care. Presumably, all DRG 107 patients had met their deductible obligations because they had to be admitted for angiography at another hospital before being referred to the demonstration hospital. DRG 106 patients may or may not have been previously admitted and paid the deductible.

Because HCFA negotiated a flat global payment for every patient receiving a bypass in a demonstration hospital, the Agency felt that every patient should be liable for the same coinsurance on physician services regardless of the amount of care they actually received. Hence, all patients (and their supplemental insurers) were liable for a fixed coinsurance equal

to 20% of the average physician portion of the global rate plus any extra Part A or B deductible that had not been met.

In simplifying payment by bundling all physician with hospital services into a single global rate, numerous problems were created both in collecting from HCFA and from third party insurers. First, difficulties arose in identifying patients covered under the rules of the demonstration. Second, delays in identifying patients led to problems in physicians accidentally billing carriers instead of submitting their bills to the hospital. Third, problems developed in receiving payment from HCFA. Fourth, even greater problems were encountered in billing supplemental insurers, including Medicaid. And fifth, significant delays in receiving payment from either HCFA or third parties resulted in severe cash flow problems.

In this chapter, the origins of each of these problems are discussed. Hospitals and HCFA overcame most (but not all) of them, leaving unresolved issues if the demonstration were to be extended to other hospitals in other cities.

15.2 Organization of Interviews

Because issues surrounding billing and collection were so prominent in the minds of hospital and physician staff, considerable time was devoted to them during the on-site interviews. Besides the manager of the demonstration at each hospital, members of hospital billing and collection departments were interviewed. Occasionally, the CFO or comptroller responded to questions concerning payment delays as well. It was clear that considerable resources had been expended in trying to collect the full payment hospitals were owed. Many staff were frustrated as well that some of the problems concerning third party payment had not been resolved even after three years. A couple of sites supplied copies of forms and lists of names from whom supplemental payment still had not been received.

15.3 Billing Advantages to Global Payment Rates

All hospitals were in agreement that consolidating all hospital and physician services into a single bundled rate was very attractive to patients. Instead of receiving lengthy, itemized, bills describing hospital and physician services, they received a single bill with no confusing list of copays they owed. The psychological advantage to the elderly of streamlining the complicated hodge-podge of bills should not be underestimated. This would be a strong advantage to expanding the demonstration to other market areas.

15.4 Problems in Identifying Patients

Medicare patients were deemed eligible for the bundled demonstration payment if they fell into either DRG 106, bypass with angiography or angioplasty, or DRG 107, bypass alone. Seemingly straightforward, this clear criterion proved difficult to implement in practice because DRG status could only be determined upon discharge. First of all, to be eligible patients in demonstration hospitals must have had a bypass, but not all patients undergoing bypasses fell in DRG 106 or 107. This is because bypass patients with "other significant surgery" were grouped into DRG 108. These included procedures like left ventricular resections, patients having an AICD generator inserted, or patients undergoing an endarterectomy on a different artery. Then there were the valve patients with bypasses as well that naturally fall in DRG 104 or 105. Hospitals might begin by identifying patients as "eligible" but then find later that they had additional surgery that excluded them.

Further complicating the DRG designation was the fact that the DRG grouper algorithms changed twice during the demonstration. The result was a very significant reclassification of DRG 108 patients back into the demonstration overtime. Not only did reclassifications confuse DRG coordinators trying to concurrently identify patients so others could manage the internal physician billing process, grouper changes also created biases in the negotiated rates. Most hospitals had submitted bids based on actuarial data on DRG 106 and 107 bypass patients alone. DRG 108 patients, which accounted for 10-20% of bypass patients in some hospitals, were ignored. When HCFA's policy branch made changes in the grouper algorithm, many more expensive patients were now considered eligible for the demonstration. The fixed negotiated rates, however, had not included these higher cost patients. HCFA did adjust hospital payment rates to reflect the change in the grouper algorithms. For an example of the algorithm used in one hospital to identify patients, see Appendix 15.

Were only a hospital bill involved, it would have been a relatively simple matter for staff to identify demonstration patients upon discharge and bill HCFA Central Office instead of their Fiscal Intermediary. Problems arose immediately from physicians seeing patients and billing the carrier before the DRG was determined. Physicians, of course, do not take DRG into consideration when billing their carriers for Medicare services. They bill on individual services. Many physician practices bill the carrier the day a service is provided. In the case of DRG 106 patients, this presented particular problems. These patients enter the hospital suffering from chest pain, chronic or unstable angina, or heart attacks. As part of their workup, a physician may initially treat the symptoms with drugs, then recommend a complete diagnostic work-up, including angiography. This often takes several days. If significant coronary artery stenosis is discovered, the cardiologist and the thoracic surgeon must decide whether angioplasty or

bypass is the appropriate procedure for a given case, if continued drug therapy is ruled out. If a bypass is agreed upon, the patient is scheduled for surgery and undergoes the operation. Only at that point is it definite that the patient has become eligible for the demonstration, although other complex surgery may put her in DRG 108 (or possibly 468 involving unrelated surgery, which is very rare for bypass patients). Further complicating identification are patients who undergo unsuccessful angioplasty and move on to bypass surgery. Thus, for a host of different reasons, from the day of admission to the day of surgery, physicians may have been seeing and billing the carrier for services rendered demonstration patients.

Hospitals had many problems at first with premature billing. In fact, physicians in one hospital still accidentally bill their carrier, and the hospital has to refund any payments once it is paid the global payment from HCFA Central Office. Staff in all institutions have established procedures for early identification of potential demonstration patients. In one instance, physician personnel identify them in their office prior to admission. For DRG 106 patients already admitted, clinical nurse specialists hired to monitor bypass patients identify patients on the floors every day. In another case, a hospital has developed what it refers to as a "walker grouper" for every DRG 106 coming out of surgery. In a third institution, utilization review staff provide a log of inpatients twice weekly to the nurse specialists to identify patients.

It appears that the two academic medical centers have fewer problems with premature physician billing due to the small number of separate practices and their inclination to wait until the patient is discharged before billing. By contrast, St. Joseph's in Atlanta has 139 separate practices to keep track of and avoid unwarranted billings to carriers. They notified the carrier not to pay physician bills until approved by the hospital to avoid having to make refunds later on.

15.5 Collecting Physician Bills

Unavoidable delays in determining patient eligibility for the demonstration have created significant problems in premature physician billings. It took most participants nearly a year to develop a comprehensive way of identifying patients and notifying and gaining cooperation from physician practices not to bill the carrier immediately for someone who might have a bypass. In the case of the four principal specialists, the surgeon, anesthesiologist, cardiologist, and the radiologist, avoiding unwarranted bills being sent to carriers was relatively simple. The problem is mainly with the other specialists who might see a demonstration patient. Once a patient has had a bypass, avoiding consulting bills is easier, but many consultants see patients before they go to surgery; hence, the importance of identifying potential eligibles up front.

No physician diagnosing or treating a demonstration patient is allowed under the demonstration to bill the Medicare carrier. If that happens inadvertently, the hospital is expected to repay the carrier for double billing. It was not possible to evaluate how much double-billing occurred under the demonstration, but the elaborate procedures used by the participants to avoid billing carriers suggests that it was minimal. How physicians were paid by the hospital out of the global fee has been discussed in Chapter 13.

15.6 Problems in Billing and Collecting the Global Fee

Most of the problems in receiving the government's portion of the global fee came early on in assembling the package of Part B bills for submission to HCFA Central Office. At first, HCFA had intended that the package include all physician bills for the inpatient stay, but this quickly proved unduly onerous on hospitals. The requirement was relaxed to require just the three principal bills of the surgeon, the anesthesiologist, and the cardiologist. This requirement was further relaxed by requiring only the surgeon's bill, which comprised half to two-thirds of the total Part B portion of the global payment.

One hospital said that it collected the surgeon's bill and the related consulting bills within 2-3 days of surgery. Anesthesiologists, however, billed the hospital with a two-week delay, resulting in a 30-day delay after discharge in billing HCFA. They were finding that it took 10-15 days after discharge to assemble a relatively complete package to submit to HCFA. Another hospital also waited 14 working days after discharge to bill HCFA. They would then bill even with only the surgeon's bill. Some variation in the completeness of the package appeared to exist across the four demonstration hospitals, which raises questions about how uniform HCFA's payment policies were.

All hospitals reported that HCFA Central Office paid promptly (with one exception noted below). Hospitals would be wired payment within 20-30 days of the submission of the bill. Thus, from the time of discharge to the receipt of payment, hospitals were receiving payment with roughly a 2-3 week delay compared to the Fiscal Intermediary for other Medicare patients. This was due to the time lag post-discharge in assembling the Part B bills.

Most hospitals developed sophisticated computer software to input all physician bills to produce a summary global package to send to HCFA for payment. Computerization was critical in order to keep track of missing bills, to make refunds to carriers who were billed mistakenly, and to pay physicians for services rendered demonstration patients. Billing and collection staff felt specialty dedicated computer systems were burdensome, but necessary, if the hospital and physicians were to continue in the demonstration as well as for bidding on private managed care contracts of a similar type. Having made the investment of time and

money in the bill tracking system, staff felt they were at an advantage compared to other hospitals without such systems.

Hospitals did report one significant problem in receiving payment from the Federal government. During the first year of the demonstration, the Congress passed the new Medicare Fee Schedule that resulted in major reductions in many inpatient physician allowable fees, including most importantly, bypass surgery. The revised fees were not implemented immediately but over a four-year transition period. In addition, the Congress also determined how fast allowable fees in general would be increased. This was complicated by the Volume Performance Standards and the differential adjustment for surgical versus medical care. HCFA Office of Demonstrations was responsible for incorporating all of these adjustments into the global payment that also included a negotiated update based on the prospective payment update factor (one hospital agreed on no update for three years). Delays in setting the allowable fee schedule updates under the demonstration, according to participants, resulted in major cash flow problems in the first quarter of 1994. One hospital said it had received no payments from HCFA in the first 4 months of 1994. In another, they had not received payment on any of the 94 patients they had discharged up to April, 1994. A third hospital reported no payments at least through March 20, 1994, when the interviews were conducted.

According to some hospital staff, requests to continue to receive payment under the old rates were denied by HCFA Central Office. The principal reason was that the Agency had not received many bills in January and February and did not want to get involved in additional adjustments later on.

The four original hospitals altogether averaged roughly 100 demonstration patients per month. If it is true that participants received no reimbursement for four months, then approximately 400 patients were involved. At an average global payment of about $25,000, this amounts to a deficit of $10,000,000. As hospitals continued to pay their physician partners during this time, as well as for their own staff and supplies, the lack of payment presented a definite financial hardship. This experience also highlights a potential problem with implementing global fees nationwide. HCFA must find ways of dealing with legislative changes in a timely manner, including the simple expedient of paying on old rates until new ones are established.

Besides this major problem, hospital billing/collection staff all felt that HCFA Central Office had been very supportive of their concerns and done just about all that they could to expedite payment. HCFA representatives visited each site and explained procedures and worked out billing arrangements. They relaxed the original requirement that all physician bills be included in the payment package. They wrote cover letters to the carriers and supplemental

insurers explaining the unique payment arrangements. They even called carriers to explain procedures and to encourage cooperation. Delays in updating rates was out of their control.

15.7 Problems Collecting the Supplemental Insurance

By far the most frustrating aspect of the process was in trying to collect the supplemental insurance owed by third party insurers for the deductible and coinsurance. Included along with payment of the global amount by HCFA Central Office would be the Explanation of Medicare Benefits (EOMB) form (see Appendix 15-B). This form is required by providers in billing either patients or their insurers for any deductible or coinsurance they may owe. HCFA Central Office would withhold the Part A deductible for a few weeks while it determined whether the patient had met their obligation on a prior admission. Because of the greater difficulties in determining the Part B deductible obligation, HCFA delayed paying the Part B deductible for up to five months, according to staff in one hospital.

The EOMB form under the demonstration differed in material ways from the one insurers were accustomed to receiving in that it combined both Part A and Part B obligations. Under the current Medicare system, hospitals and physicians submit separate bills to Fiscal Intermediaries and Carriers. Part A and B obligations, therefore, are automatically separate (although both EOMB's usually go to the same supplemental insurer for a given patient). More confusing, however, was the absence of any procedure codes, submitted charges, allowed amounts, or any reasons for disallowances that accompany regular EOMBs. Supplemental insurers were being asked to pay a single, uniform, coinsurance on Part B services regardless of the procedures performed or what amount the physician decided to bill.

As might be expected, nearly all insurers balked at such a novel arrangement. Most said that the billing form lacked detail and, hence, was incompatible with their long-standing computer systems. These systems required that each procedure of each physician be identified separately so that service coverage and reimbursement screens could be applied. Besides, different patients, they said, had different deductible and coinsurance obligations. Other insurers were more indignant, pointing out that "they didn't agree to participate in the demonstration" and weren't going to process the EOMBs.

HCFA demonstration staff made concerted efforts to encourage supplemental insurers to accept the demonstration EOMB form. Appendix 15-C provides a facsimile of the letter provided to participants explaining the program to insurers. It requests that the insurer not pay the physician directly because they have already been paid under the demonstration. It also emphasizes that the hospital, not the physician, is responsible for collecting the Part B coinsurance amounts, which is novel. While it does mention that no detailed procedure

information is supplied, no reason is given for the missing information or how the insurer should input the aggregated amount into their computer system for future reference. Under a section explaining how the aggregate patient/insurer liability was determined by HCFA, it is emphasized that the "one Part B coinsurance amount for each DRG [is] less than what the combined amount would otherwise be for heart bypass surgery performed by these providers outside the demonstration. Thus, the supplemental insurer liability is reduced." Of course, this was true only *on average*. Some patients may have incurred physician bills that were less than the actuarial amount determined by HCFA, a point insurers were quick to make.

One hospital, and possibly others, responded to insurer objections by sending a package to each insurer that included the EOMB, a letter from the Medicare CABG clerk explaining the unusual EOMB form, the letter drafted by HCFA staff explaining the demonstration, the standard UB-82 form for Part A payment, a letter from the thoracic surgeon, and a complete set of relevant HCFA-1500 Part B physician forms detailing the procedures performed by HCPCS code, the physician's charge, and other relevant information. Over time, as insurers received more of these "global EOMBs", they have made accommodations. Nevertheless, collecting Part B coinsurance amounts have been delayed several months at least, generating a significant administrative and cash flow burden for all hospitals.

Private supplemental insurers have been a problem that has been addressed at least with some success. Medicaid in at least two of the states has been even more difficult. This is ironic in that it is a public program more than half funded by the federal government. The Medicaid programs in Michigan and Ohio have refused to pay any supplemental insurance obligations. As part of the OBRA 1990 law, Medicaid has been required to pay for the deductibles and coinsurance of the poor elderly. Michigan and Ohio refuse to accept the global packaged rates negotiated by HCFA, arguing that the actuarial amount allowed under the demonstration exceeds their own allowable for the procedure. Faced with a novel EOMB form and a single aggregated amount, these states have balked at paying the demonstration hospitals anything to date. The hospital, not the physician, has absorbed the loss.

Billing/collection staff find the whole process very frustrating. If physicians were allowed to bill supplemental insurers directly, they could be paid immediately. HCFA has been unwilling to let physicians bill insurers (or uninsured patients) directly for fear that billings may exceed the actuarial amount of the fixed patient obligation based on the negotiated fee. This could arise if some patients use more services, or some physicians have especially high allowable fees, or if physicians offered significant discounts to be part of the demonstration yet bill their full allowable fee.

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